

GenRad

RANDOM

VIBRATION CONTROL OPERATING MANUAL 2511 AND 2500-SERIES VIBRATION CONTROL SYSTEMS

Publication No. 2511-0120/5

Revision 5

June 1986

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Printed in U.S.A.

GenRad, Inc.
Milpitas Facility
510 Cottonwood Drive
Milpitas, CA 95035

Telephone (408) 946-6960

List of Effective Pages

Original:	August 1983
Revision 1:	June 1984
Revision 2:	August 1984
Revision 3:	March 1985
Revision 4:	September 1985
Revision 5:	June 1986

This manual contains 200 pages consisting of the following:

<u>Page Number</u>	<u>Revision Level</u>
Title	5
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1-1 thru 1-14	5
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REVISION RECORD

1. Original release August 1983. Initial software version V1.0.
2. Revision 1 release June 1984, released in conjunction with software version V1.1.
3. Revision 2 release August 1984, released in conjunction with software version V1.2.
4. Revision 3 release March 1985, released in conjunction with software version V2.0.

Pages 2-69 through 2-74 and pages 3-8 through 3-76 in revision 2 have been renumbered 2-70 through 2-77 and 3-9 through 3-85 in revision 3. The page numbers given below refer to the new pagination in revision 3.

Minor changes and corrections to typographical errors are made on pages 2-24, 2-42, 2-45, 2-66, 2-69, 2-72, 2-76, 3-1, 3-5, 3-9, 3-32, 3-37, 3-38, 3-39, 3-43, 3-65, 3-68, 3-75, 3-76, and 3-84.

The setup function dialog now includes both upper and lower case. This is reflected in the contents of figures and dialog excerpts on pages 3-3, 3-4, 3-5, 4-6, 4-8, 4-11, 4-13, 4-14, 4-16, 4-17, 4-18, and 4-19. The header and comments setup parameters may include both upper and lower case characters, and the STATE,C characters are provided as a toggle switch between upper and lower case input: this is described on pages 2-53, 3-5, 3-9, and 3-35.

An expanded edit capability is provided for the header and comments setup parameters. This has resulted in altered functions for several special control characters. Altered functions for the MARK key are described on pages 2-53, 2-68, 3-9, 3-35, 3-77, and 3-78. Altered functions for the ARROW keys are described on pages 2-54, 3-9, 3-35, and 3-78.

A discussion of overshoot in the drive signal that results from, and partially undoes the effect of, drive signal clipping is given on page 2-30.

An expansion of the tolerance bands menu parameter is provided from the previous OFF/ON values (ON = display alarm bands) to new OFF/ALARM/ABORT values (allowing choice of displaying alarm bands or abort bands). This is described on pages 2-57, 2-63, 3-46, and 3-51.

The test ID, test heading, run #, and test comments parameters that annotate the spectrum display have been re-arranged. The new arrangement is noted on pages 2-61 and 2-62.

If the BANDWIDTH or RESOLUTION setup parameters are modified via the CORRECTIONS procedures, then any spectra currently stored in memory are zeroed; and if pre-stored drive is currently active it is disabled. This is done to prevent inadvertant use of inconsistent data if a test with pre-stored drive is initiated following the parameter modification. This is described on pages 3-10, 3-11, and 3-36.

In modifying the reference spectrum, positive increments to the reference level of greater than +6 dB are rejected due to the possibility of loss of control in attempting to equalize to a change of this magnitude. This is described on pages 3-57 and 3-58.

A cursor with frequency and amplitude readout has been added to the data replay display, and is described on pages 3-76 and 3-78.

The post-test message contents have been expanded, as described on pages 3-62 through 3-65.

The largest change in revision 3 is the addition of a test log function that stores the expanded post-test messages on disk as a test log file. This has involved new paragraphs 3.5.3 and 3.10 and changes on pages 1-7, 1-13, 2-3, 2-56, 2-59, 2-64, 2-68, 2-69, 3-46, 3-65, and 3-79 through 3-83. New program messages pertaining to the test log function are contained on pages 2-74 and 2-76. A report generation program to provide a summary listing of the contents of a test log file is identified and discussed on pages 1-2, 2-69, and 2-70.

5. Revision 4 release September 1985, released to reflect software version V2.1.
6. Revision 5 release June 1986, released to reflect software version V2.3.

Random version 2.3 reflects the following changes: HP-GL support; the program checks for a default setup parameter file on disk and retrieves it if it is found; the setup editor can be locked with a password so that no changes can be made to the setup parameters in memory; and the level scheduling profile can be looped any number of times.

PATENTS

U.S.	3,710,082
	3,848,115
U.K.	1,397,334
	1,470,000
France	74,33688
West	2,220,416
Germany	24 44 101
Japan	112 5154
	88 9091

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SECTION I

DESCRIPTION

1.1 INTRODUCTION

This document describes RANDOM, the Random Vibration Control program for the GenRad 2511 or 2500-series Vibration Control Systems. RANDOM performs random vibration control tests and evaluations of external loads (usually a shaker and test specimen).

This revised Version 2.3 reflects the following: HP-GL support so that HP-GL compatible plotters can be used with Random; the default setup parameters file, RANDOM.RN, is retrieved by the program when it is first run; the setup editor can be locked with a password so that no changes can be made unless the password is known; the Level Scheduling option of level profiling can be looped any number of times; and general reformatting of the entire manual to maintain consistency with GenRad established publication guidelines.

This manual is divided into four sections: Description, Theory of Operation, Operating Procedures, and Receiving Checkout Test.

The Description section provides information on the hardware and software supplied, external signal connections, a summary of software specifications and functions, and the loading procedure for the RANDOM program.

The Theory of Operation section gives a detailed functional description of the RANDOM program including all program features and options.

The Operation section describes how to set up and perform Random Vibration Control test and analysis functions. The procedures begin with the setup procedure that describes how to enter random vibration control test parameters. Loop check and detailed test function procedures are then described, followed by operating procedures for post-test documentation, the analysis of input signals, and the retrieval of test data from disk.

The Receiving Checkout Test procedure demonstrates the system performance capability before the system is connected to an external load. In these procedures, a known set of parameters is used to determine that the system is properly installed and operational. Use the Receiving Checkout Test for familiarization with the system controls and procedures.

1.5 CAPABILITIES SUMMARY

The GenRad Vibration Control Systems provide safe and accurate digital, closed-loop, random vibration control testing using true Gaussian random waveforms. The analog input and output circuitry are automatically programmed for maximum dynamic range. The disk drive allows rapid program loading, test setup, data storage, and data recall for off-line analysis. The terminal includes a full ASCII keyboard and a raster-scan CRT for realtime displays.

The RANDOM program continuously provides information necessary to monitor and interact efficiently with the testing process. All operations are set up and controlled by program driven menus using the keyboard and CRT. You can observe the control, drive, and other spectra while a test is in progress and perform realtime test modification and control. All spectrum displays are fully annotated and calibrated and can be saved on disk for future review.

The RANDOM program has an operator friendly interface. The system is easy to learn and use; all control is concentrated at the keyboard and CRT. There is a wide range of test setup parameters providing great flexibility in testing. These parameters can be readily established, modified, and saved for later use. The program includes the following specific characteristics:

CONTROL FREQUENCY RANGES

Seven ranges from dc to the following upper frequencies: 200 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, and 8000 Hz.

SPECTRUM RESOLUTION

Choice of 100, 200, or 400 lines of resolution over any of the seven frequency ranges (600 or 800 lines of resolution optional with extra memory).

SPECTRUM DISPLAYS

Control, monitor, reference, drive, error, and auxiliary spectra, also transmissibility and inverse transmissibility functions. All displays are annotated and fully calibrated. Display contents can be copied onto optional hardcopy device.

REFERENCE SPECTRUM

Defined by up to 40 operator defined breakpoints, or can be an actual measured spectrum developed from one or more input channels.

CONTROL LOOP AVERAGING

Selectable number of new frames per loop (N) and exponential discount factor (K).

CONTROL CHANNELS

A maximum of 16 input signals from accelerometers may be used for control with rms averaging or peak-hold averaging (optional 16-channel

selector required). The control spectrum is generated as the average of the individual control channel source spectral densities (PSD's). Accelerometer sensitivities (in mv/g) may be individually specified for each channel.

EQUALIZATION ACCURACY AND TIME

Control is accurate to within ± 1 dB of the reference spectrum for $N=4$ and $K=3$. An instantaneous change of 10 dB in the entire reference spectrum will be re-equalized to within ± 3 dB in two control loops for $N=4$ and $K=3$.

DATA STORAGE AND RETRIEVAL

Test setup parameters may be saved on disk for use in subsequent tests. During test or analysis function execution spectra may be stored for later off-line data replay.

PRE-EQUALIZATION

For testing of identical or similar loads, a previously developed drive spectrum can be retained and used as the initial drive signal on the next test to speed the control process.

ON-LINE SPECTRUM MODIFICATION

Any single spectral line or contiguous frequency band in the reference spectrum can be changed during a test. Re-equalization to the modified reference occurs automatically.

AMPLITUDE SCHEDULING

A level profile of up to 32 drive signal amplitudes and durations can be set-up and repeated, or a repetitive amplitude cycle between full level and a specified cycle low level, can be defined.

TEST SCHEDULING

Tests can be run singly, or up to 63 tests can be entered in a schedule and run automatically. With the addition of the optional Remote Communications Interface the tests may be selected and executed under control of a remote device.

TEST LOGGING

Post-test messages may be written to a disk file to provide a summary of program test activities.

The above characteristics and other program features provide a comprehensive, flexible, and versatile random vibration control test capability.

1.5.1 Control Loop

The RANDOM program uses Fast Fourier Transform (FFT) techniques to control the external load. The program generates a randomized digital signal that is converted to an analog drive signal and sent to the drive amplifier of the shaker equipment to excite the device under test. The control system then accepts analog response signals from the external load accelerometer amplifiers, digitizes the analog signals, and computes a power spectral density (PSD) function using the FFT algorithm. This PSD function, called the control spectrum, is compared with a reference spectrum stored in the system memory. The reference spectrum represents the desired excitation for the external load. The difference between the control and reference spectra is used to generate a compensated drive signal. This process, the control loop of the program, continues throughout the duration of a test so that the control spectrum (which indicates the actual excitation of the external load) is made to be equal or very close to the reference spectrum. Figure 1-2 illustrates the steps in the control loop.

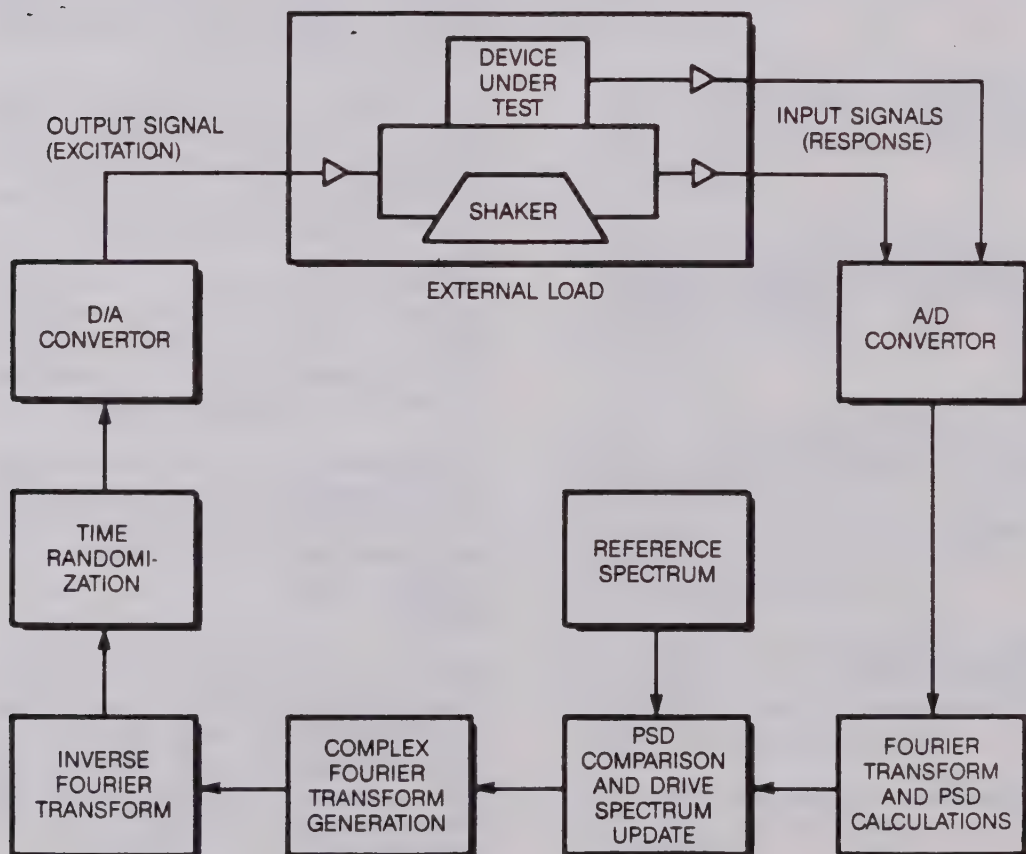


Figure 1-2. Random Vibration Control Loop, Simplified Diagram

1.5.2 Safety Features

The program has a full range of safety features to detect abnormal test conditions and to generate alarms or initiate a controlled and documented abort when necessary to protect the external load. The protection and safety measures are continually active and include the following features:

- o Pre-test loop check to detect open or noisy control loop conditions.
- o Selectable alarm and abort tolerance bands defined by alarm and abort limits for individual spectral lines.
- o Alarm and abort level for the overall control spectrum.
- o Abort on loss or excessive fluctuation of control signal.
- o Manual test abort.
- o Drive signal clipping prevents the drive signal level from exceeding a pre-determined value.
- o Optional interface to accept external alarm or abort signals.
- o Audible alarms to alert you to abnormal test conditions.
- o Smooth test shutdown to reduce transients under abort conditions.
- o Power fail detection.
- o Abort message for post-shutdown analysis.

1.6 EXTERNAL SIGNAL CONNECTIONS

This paragraph identifies the required external signal connections that are pertinent to the RANDOM program. For the connection of other system equipment, refer to the appropriate system description manual.

1.6.1 Inputs from External Load

Connect the input signals to A/D channel connectors 1 through 4 on the front or rear panel of the 2511 chassis, or to A/D channel connectors 1 through 16 on the front or rear of the A/D chassis for 2500-series systems. Channels 2 through 4 are optional for 2511 systems; channels 3 through 16 are optional for 2500-series systems. If the optional 16-channel selector unit is present and in use, see paragraph 1.6.4 below.

1.6.2 Output to External Load

Obtain the output signal from the connector labelled DRIVE on the front or rear panel of the 2511 chassis, or on the front or rear panel of the D/A chassis for 2500-series systems.

1.6.3 Clock Signal for D/A

For 2511 systems, install a cable between the A/D Clock Out and the D/A External Clock connectors in the rear panel.

For 2500-series systems, install a cable between the DAS SYNC and SYNC IN connectors on the rear of the A/D-D/A chassis.

1.6.4 Optional 16-Channel Selector

For 2511 systems, make the following connections:

1. Install the cable from the 16 CHANNEL SELECT connector (part number 2511-3015) to the 16 CHANNEL SELECT connector on the chassis rear panel.
2. Connect the input signals from the external load to the connectors labelled CH 1, . . . CH 16 on the selector assembly.
3. Install a cable between the SELECTOR OUTPUT connector on the selector assembly and the A/D channel 1 connector on the front or rear of the 2511 chassis.

Note: This connection replaces all connections of paragraph 1.6.1 above. When the 16-channel selector is in use, all A/D inputs on the chassis except channel 1 are ignored.

For 2500-series systems, make the following connections:

1. Connect the small round cable leaving the A/D chassis to the connector labelled POWER on the selector assembly.
2. Connect the input signals from the external load to the connectors labelled CH 1, . . . , CH 16 on the selector assembly.
3. Install a cable between the SELECTOR OUTPUT connector on the selector assembly and the A/D channel 1 connector on the front or rear panel of the A/D chassis.

Note: This connection replaces all connections in paragraph 1.6.1. All A/D inputs except channel 1 are ignored.

1.6.5 Optional Remote Communications Interface

To install the Optional Remote Communications Interface on 2511 systems, make the following connections:

1. Connect the FROM REMOTE cable leaving the rear of the interface assembly to the connector labelled FROM REMOTE on the chassis rear panel.

2. Connect the TO REMOTE cable leaving the rear of the interface assembly to the connector labelled TO REMOTE on the chassis rear panel.
3. Connect remote control lines and external alarm/abort lines to the CMD LINES 1 through 16 on the interface assembly.
4. Connect STATUS LINES 1 through 16 on the interface assembly to the status inputs on the remote device. (Use of the status output lines is optional and conditional on the ability of the remote device to accept and use status indications from the RANDOM program.)

For 2500-series systems; make the following connections:

1. Connect remote control and external alarm/abort lines to the J1 through J16 connectors on the INPUTS FROM REMOTE DEVICE panel mounted on a rear rack rail.
2. Connect status lines from connectors J1 through J16 on the STATUS TO REMOTE DEVICE to the status inputs on the remote device. These lines need be used only if the remote device is equipped to accept status information from the RANDOM program.

1.6.6 Optional Digital Plotter

For 2511 systems, install a cable between the RS232 Port 3 connector on the chassis rear panel and the RS232 MODEM connector on the rear of the plotter. For 2500-series systems, connect the plotter cable leaving the system controller chassis to the RS232 MODEM connector on the plotter.

1.7 SOFTWARE INSTALLATION AND RESTART

The standard diskette (2511-0620) containing the RANDOM program contains a copy of the software operating system and a start-up file that automatically starts the program when you execute the system bootstrap loader.

To run the program, insert the diskette and press the BOOT switch. After preliminary messages output by the start-up file or the operating system display, the RANDOM program loads and starts executing in its standby state.

To stop the program and return to the operating system, the program must be in standby. Press the MENU key on the keyboard to execute the program EXIT function. Use the + or - key to set the function parameter to EXIT, and press the EXECUTE key. The RANDOM program then terminates execution and returns control to the operating system.

To restart the RANDOM program enter the following command at the keyboard:

```
RUN dev:RANDOM
```

The quantity "dev:" is the code for the device on which the program diskette resides, e.g., "DY0:". The program loads and set into execution in the standby state.

1.8 RANDOM SPECIFICATIONS

The Random Vibration Control program conforms to the following specifications when used on 2511 or 2500-series systems with the standard hardware configurations as noted in paragraph 1.4.

1.8.1 Output Characteristics

Frequency Range	0 to 8 kiloHertz
D/A Convertor Resolution	12 bits
Output Amplitude Dynamic Range	>60 decibels
Attenuator Resolution	12 bits
Output Amplitude Resolution	0.1 decibels (over 0 dB to -36 dB)
Output Impedance	50 ohms
Maximum Output	2.4 volts root mean square
Minimum Recommended Output Level for Control	±10 millivolts

1.8.2 Input Characteristics

Number of Inputs	1 (up to 16 with optional hardware)
A/D Convertor Resolution	12 bits
Input Amplifier Dynamic Range	>60 decibels
Input Ranges	125 millivolts to 8 volts full scale, in 8 binary ranges
Input Impedance	1 megohm shunted by <100 picofarads
Maximum Input	±10 volts
Minimum Recommended Input Level for Control	±10 millivolts

1.8.3 Equalization and Control Characteristics

Maximum Control Bandwidth	8 kiloHertz
Frequency Resolution	100, 200, or 400 lines (600 and 800 lines with optional memory)
Control Dynamic Range	60 decibels

Reference Spectrum	Defined by an initial slope, up to 40 breakpoints, and a final slope. Each breakpoint is specified either as a signal level (in G^2/Hz) and frequency, or as a slope. Also defined by measured spectrum derived from real input data. Such a spectrum can have more than 40 breakpoints.
Alarm Limits	Selectable in $\pm dB$ above and below each segment of the reference spectrum. Exceedance during test causes an audible alarm.
Abort Limits	Selectable in $\pm dB$ above and below each reference spectrum segment. Exceedance during test causes automatic test termination.
Equalization Accuracy	Control to within $\pm 1 dB$ for a flat transfer function with 120 degrees of freedom.
Equalization Speed	An instantaneous change of 10 dB for the entire reference spectrum equalizes to within $\pm 3 dB$ within 2 correction loops.

1.8.4 Control Strategies

Control of the test article is based on the average of up to 16 input signals. The composite control spectrum can be formed from the linear average of the individual input signals or as the maximum value for each frequency line of the individual signals.

Control loop averaging may be controlled by selecting the number of data frames (N) per control loop and the exponential discount factor (K) for combining new and previous spectra.

Reference spectrum modification during a test is provided. Equalization to the new reference begins automatically as soon as the modification is made.

Pre-equalization is available for repetitive testing of similar test articles. The drive spectrum that produced equalization can be retained for use in the next test so that re-equalization is rapid or unnecessary.

A measured reference spectrum can be computed using real input data obtained from one or more channels.

1.8.5 Test Amplitude Parameters

The program includes the following selectable parameters that regulate the drive signal amplitude during a test:

Test low level	Initial drive signal level at which equalization first occurs.
Auto or manual start	Allows test to leave low level automatically after a specified time, or to remain at low level until your command is received.
Level increment	The step size ΔL (in dB) for each change in drive signal amplitude when the amplitude goes from one level to another.
Auto or manual advance	Allows the test either to transition automatically from low level to full level, or to require your command for each ΔL level change.
Startup and shutdown times	The time in seconds for the auto advance from low to full level, and the transition time from the final test level to drive off at the end of the test.
Level change capability	You can manually decrease the drive signal level below full level in steps of ΔL , and can increase the level back to (but not above) full level.

1.8.6 Amplitude Strategies

Three amplitude test strategies are available: a standard (unscheduled) test and two types of level scheduling: level profiles and level cycles.

Unscheduled test	The test advances from low level, remains at full level for a specified time, and then shuts down.
Level profile	After leaving the low level, the test dwells at a sequence of up to 32 levels for specified times. Following the final level test, shutdown occurs.
Level cycles	Includes a complete unscheduled test, following which the drive signal level cycles for a selected number of times between full level and a specified cycle low level. Shutdown then occurs.

1.8.7 Test Scheduling

A table of up to 63 test names can be constructed, where each name corresponds to a file of test parameters stored on disk. The schedule can then be executed, causing all included tests to be automatically run in sequence without need for operator action between tests.

1.8.8. Remote Control

Requires optional remote control interface hardware. Allows the tests in a schedule file to be executed by a remote device such as a thermal chamber controller.

1.8.9 Disk Storage and Retrieval

Setup parameters	The parameters that completely define a test can be stored on and retrieved from disk as a parameter file.
Test schedule	Names of tests to be run in an automatic sequence can be stored in a schedule file.
Spectra	The spectra formed during a test can be stored on disk as a data file, for later retrieval by the data replay function.
Post-test messages	The post-test message produced at the conclusion of each test can be stored on disk as a test log file. The file can then be read and a report generated from its contents.

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SECTION II

THEORY OF OPERATION

2.1 OVERALL FUNCTIONAL DESCRIPTION

2.1.1 Definition of RANDOM Vibration Testing

Random vibration testing is a type of testing using digital vibration test equipment made possible by the development of the computer (especially the mini-computer) and of the fast Fourier transform (FFT). Random testing excites many modes simultaneously because the excitation signal contains a broad band of frequencies whose individual amplitudes are constantly changing.

The FFT, a mathematical procedure for calculating the Fourier transform, provides a practical means of taking advantage of the duality of time and frequency in analyzing signals. Every repetitive, cyclic curve can be exactly reproduced by a unique combination of simple sinusoidal functions (sines and cosines) and can be applied to any time signal. The signal can then be analyzed into pure frequencies (time $\rightarrow$ frequency, using a Fourier transform operation), or a combination of pure frequencies can be selected to synthesize any time signal (frequency $\rightarrow$ time, using an inverse Fourier transform). Figure 2-1 illustrates this concept.

The applicability of this time-frequency duality to digital Random vibration test systems is as follows:

The desired reference spectrum, and an excitation spectrum that produces a response from the test item matching the reference spectrum, are established as frequency functions within the system.

The excitation spectrum is synthesized to form a time signal, and is output to the actuator equipment. The response is acquired from the test item as a time signal and is analyzed into a frequency spectrum. This response spectrum is then compared with the reference spectrum. Any difference between the two is used to correct the next excitation spectrum, which is then synthesized into a time series and output to the shaker, and so on. This, in brief, is the operation of the control loop maintained by the GenRad RANDOM Vibration Test System.

2.1.2 Major Program Functions

The operations of the RANDOM vibration control program are grouped into a set of nine program functions. All activities associated with a RANDOM vibration test are carried out as one or another of these functions. The functions, in typical order of execution, are:

- Standby
- Setup
- Loop check
- Test
- Post-Test

Data replay
 Analysis (open loop)
 Test Log
 Exit

2.1.2.1 Standby. When the RANDOM program is running but no function has been selected, the program is in standby state. When a function is selected, the program leaves standby to execute the function. When the function is completed (or terminated by you) the program returns to standby and awaits your command to execute another function.

2.1.2.2 Setup Function. In the setup function major test parameters required for a RANDOM vibration test are entered into the program. This must be done before executing any of the other functions. Parameters may be entered from the system keyboard, or from a previously created set of parameters stored on disk.

2.1.2.3 Loop Check Function. The loop check function is a continuity test of the signal connections required for closed-loop control. The loop check should be applied to an external load before the load is subjected to a full test.

2.1.2.4 Test Function. The test function is the closed-loop control of an external load, with spectrum equalization to the reference spectrum.

2.1.2.5 Post-Test Function. The post-test function is used to request a post-test summary of test results at the end of a test, whether completed normally or aborted.

2.1.2.6 Data Replay Function. The data replay function allows retrieval of spectra that were stored on disk during a test. Data replay allows post-test inspection of the conditions that existed at various points throughout the duration of the test.

2.1.2.7 Open-Loop Analysis Function. The open-loop analysis function does not perform closed-loop control and no excitation signal is output to the external load. The analysis function acquires data from the load and computes an auxiliary spectrum and monitor spectrum. This continues for a duration equal to the test time parameter, at which time the program returns to standby. While the analysis function is active, the auxiliary and monitor spectra may be displayed and examined. Since no drive signal is generated when the analysis function is executed, the control signals must either result from your excitation of the external load, or must come from the analog tape playback of signals recorded during a previous test.

2.1.2.8 Test Log Function. The test log function allows storage in a disk file of the post-test message produced by the post-test function.

■ **2.1.2.9 Exit.** Leave the RANDOM program and return to RT-11.

2.2 TIME SERIES ANALYSIS PARAMETERS

The operations performed by the system on the excitation and response signals, and the digital/analog and analog/digital conversion processes involved in outputting and acquiring these signals, are part of the branch of mathematics called time series analysis. A knowledge of certain time series analysis parameters facilitates understanding the operation of the RANDOM vibration control program.

2.2.1 Acquisition of Response Signal

A response signal $x(t)$ received by the system from an accelerometer mounted on the device under test is a continuous, time-varying voltage. The system digitizes this continuous signal by sampling it at times $t_0, t_1, t_2, \dots$ that are equally spaced in time, and by keeping a record of the signal values at each sampling time. This set of signal values $x_0, x_1, x_2, \dots$ is a time series. Figure 2-2 illustrates the sampling process and the production of a time series. The quantity Δt between successive sampling times is called the sampling interval. The inverse of the sampling interval is called the sampling frequency and is denoted by S ($S=1/\Delta t$). S gives the number of samples taken per second.

The signal $x(t)$ cannot be sampled indefinitely for any real experiment, so some finite number of samples are acquired and analyzed. Such a set of samples, representing a portion of the signal, is called a frame. The number of samples M in a frame is called the frame size. The total time T required to collect the frame is the frame acquisition time. It is related to the other parameters by the expression $T = (M) \times (\Delta t)$.

2.2.2 Degrees of Freedom

Typically, a sampled frame of a time signal covers only a small portion of the original signal. In this case, the probability that the characteristics of the frame represent the true characteristics of the signal may be small. This probability, the statistical accuracy of the frame, is measured in degrees of freedom (DOF). The DOF value associated with a sampled frame depends on the number of samples (M) in the frame. The DOF may be increased by sampling more of the original signal, for example by acquiring several frames and averaging them together. It may also be increased by sampling more frequently (by decreasing Δt) so that there are more samples in each frame. Both of these sampling parameters (the number of frames acquired and the frame size) are selectable when you are conducting a vibration test.

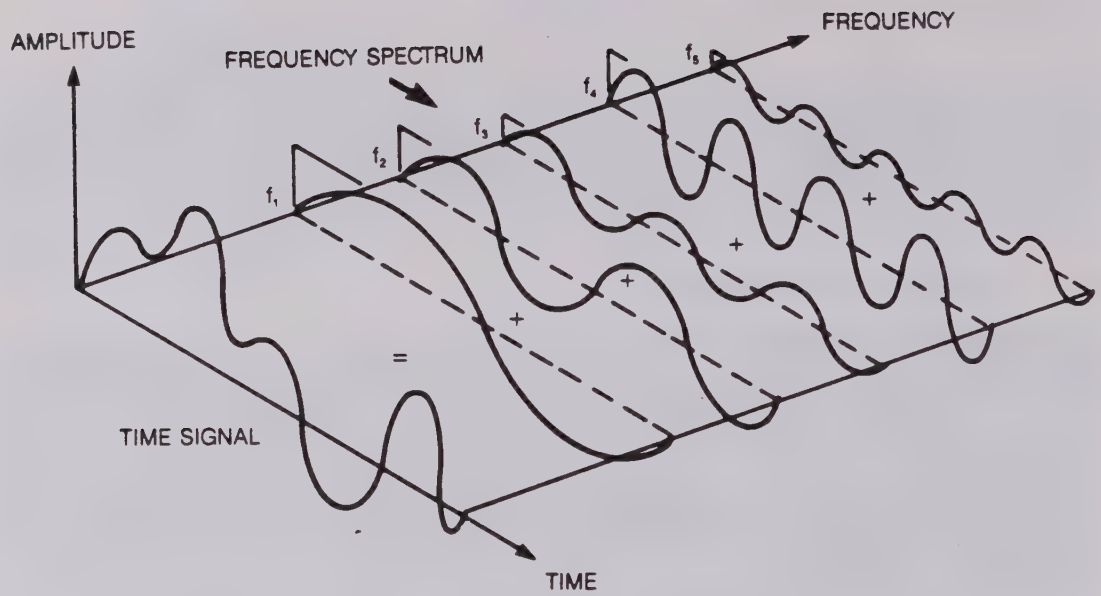


Figure 2-1. Time-Frequency Duality

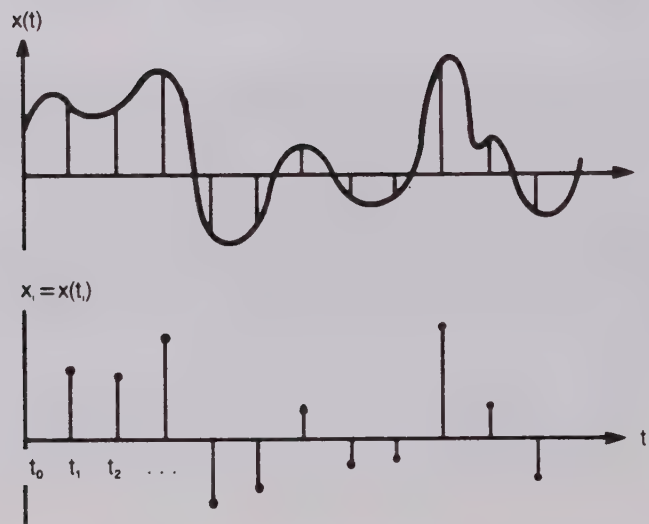


Figure 2-2. Continuous Time Signal Sampling

2.2.3 Outputting the Excitation Signal

Generation of an output signal is analogous to acquisition of an input signal. The output signal is computed within the system as a time series. A number of successive values of the series constitutes an output frame, and these values are output to a d/a convertor at a certain output frequency to produce a portion of an analog output signal. (In the case of output there is an additional item of hardware, a high-performance analog smoothing filter that converts the shape of the analog excitation signal from a staircase function to a smooth curve.)

2.2.4 Fourier Series

Suppose that a continuous time signal $x(t)$ is sampled with a sampling frequency S at times t_i ($i = 0, 1, 2, \dots, M-1$) to form one frame of a time series containing the M values $x(t_i)$. A Fourier series, a frequency function denoted by $X(f)$, can then be calculated from the time series frame using the fast Fourier transform (FFT) algorithm, as follows:

$$X(f_k) = (1/M) \sum_{i=0}^{M-1} x(t_i) \exp(-j2\pi i k/M)$$

where there are $M/2$ values of k ($k=0, 1, 2, \dots, (M/2)-1$)
and where M is the number of points in the time series frame

A characteristic of the above formula is that a time series frame containing M values equally spaced in time, produces a Fourier series containing $M/2$ frequency values equally spaced in frequency. The frequency range covered by the Fourier series, called the bandwidth of the series, is from 0 Hz (DC) to a maximum frequency B Hz. The value of B is related to the sampling frequency of the original time series frame by the relation

$$B = S/2$$

The frequency interval Δf between successive values in the Fourier series is its resolution. The resolution is defined as the maximum frequency divided by the number of values in the Fourier series, or

$$\Delta f = B/(M/2) = 2B/M$$

This formula can be developed further using the fact that $B=S/2$ and $S=1/\Delta t$, to show the relationship between the various time series analysis parameters:

$$\Delta f = 2(S/2)/M = S/M = 1/M \Delta t = 1/T$$

where T is the acquisition time of the original time series frame.

The degrees of freedom (DOF) of a Fourier series varies inversely with the frequency resolution of the series. The DOF is thus increased by a smaller resolution, which in turn results from a larger frame size and a lower sampling rate.

The original signal time series frame can be re-derived by computing the inverse Fourier series, which converts a frequency function back to a time-dependent value:

$$x_i(t) = X^{-1} \{ X(f_k) \} = \sum_{k=0}^{(M/2)-1} X(f_k) \exp(+j2\pi k/M)$$

The Fourier series and inverse Fourier series are true inverse functions of each other and illustrate the duality of time and frequency functions.

2.2.5 Power Spectral Density (PSD)

A Fourier series is a complex frequency function with both magnitude and phase. The frequency function used in the RANDOM vibration control program is not the Fourier series but the Power Spectral Density (PSD) function. The PSD is a real frequency function having magnitude only and is denoted by $S_X(f)$. It is formed as the absolute value of the Fourier series:

$$S_X(f) = \{ X^*(f_k) \} \{ X(f_k) \}$$

where $X^*(f_k)$ is the complex conjugate of $X(f_k)$.

The PSD has the same bandwidth, number of lines, resolution, and DOF as the Fourier series from which it is calculated. Although any frequency function may be called a spectrum, the term spectrum as used here specifically means a PSD. All spectra referred to in this document are PSD functions.

2.3 RANDOM VIBRATION CONTROL LOOP

The RANDOM Vibration Control program performs digitally controlled random vibration tests using fast Fourier transform techniques. The system generates a randomized digital signal that is converted to an analog drive signal and sent to the drive amplifier of an external load (shaker and device under test). The system then accepts analog control signals from the external load accelerometer amplifiers, digitizes these analog signals, and compares an averaged power spectral density (PSD) spectrum derived from this digitized signal with a reference spectrum stored in system memory. A compensated drive signal is then generated and returned to the external load. These operations continue throughout the duration of a test so that the control signal spectrum is brought into and maintained in close equivalence with the reference spectrum. The process of achieving this equivalence between control and reference spectra is called equalization of the drive signal and is a key part of the vibration test process.

Figure 2-3 shows the processes involved in the control loop. The functioning of the loop may be explained by describing the operations that take place in each of the identified steps in the process, starting with the output of a drive signal to the external load. The numbered paragraphs 2.3.1.1 through 2.3.1.9 that follow correspond to boxes (1) through (9) in Figure 2-3.

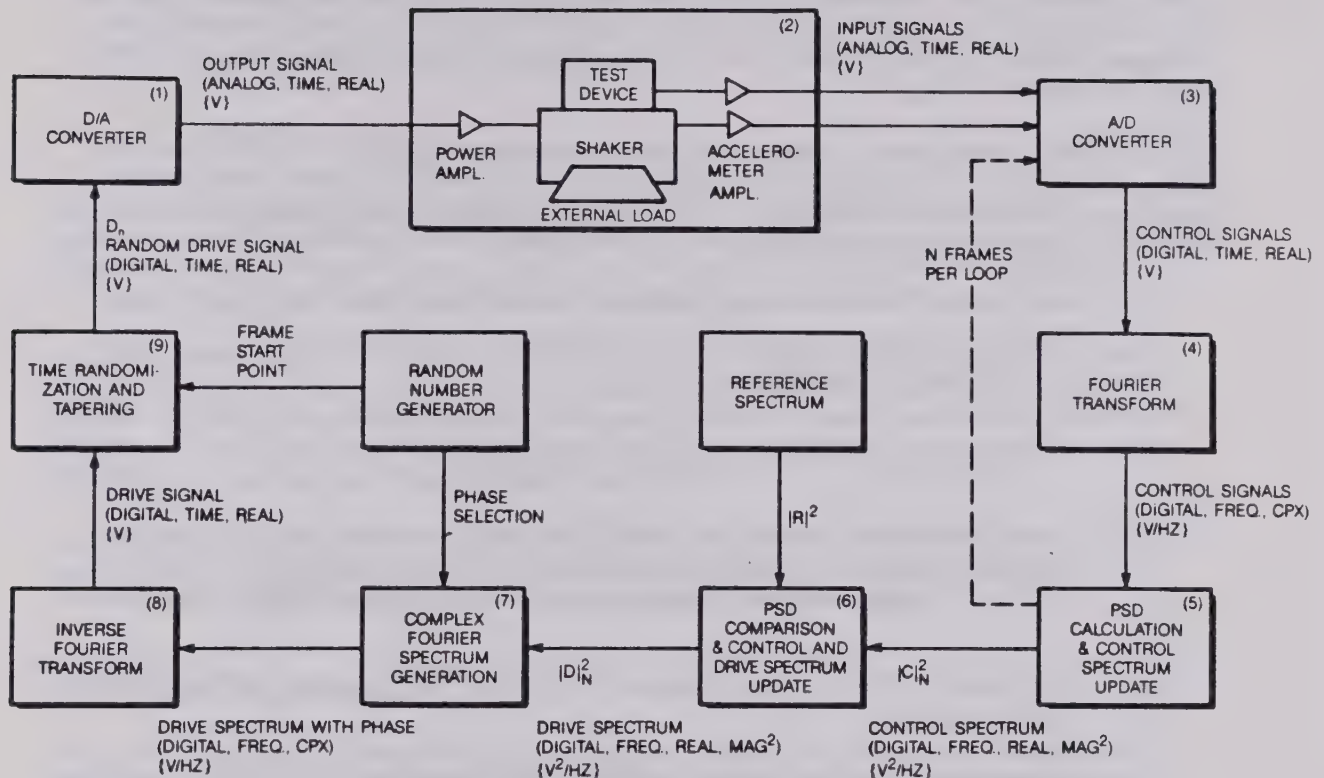


Figure 2-3. Random Vibration Control Loop Diagram

2.3.1 Loop Stages and Update Equations

2.3.1.1 D/A Converter. During the loop, the current drive signal is continually converted to analog form and transmitted to the power amplifier of the shaker via the system output channel.

2.3.1.2 External Load. The external load includes the shaker apparatus and the device under test. A single output channel carries the drive signal that excites the load. Accelerometers can be attached to from 1 to 16 points on the load to provide the excitation response from these points. These are the input signals that are acquired by the system via input channels.

2.3.1.3 A/D Converter. The input signals are digitized and become time series frames. You select any combination of one or more input channels as control channels, to be used to equalize to the reference spectrum.

2.3.1.4 Fourier Transform. Each digitized control signal frame is transformed to a complex Fourier series via the FFT algorithm. The transformation is performed so that drive equalization can be carried out in the frequency domain.

2.3.1.5 PSD Calculation and Control Spectrum Update. Each Fourier function is converted to a PSD function. Steps (3), (4), and (5) are repeated N times for each control channel; the resulting N PSD's for each channel are combined to form a single averaged PSD. If more than one control channel has been selected, the averaged PSD's for each channel are further averaged together to form the new control spectrum $|C|_N^2$.

2.3.1.6 PSD Comparison, Control, and Drive Spectrum Update. The equalization process consists of modifying the drive spectrum until the control spectrum is identical to the reference spectrum. The reference spectrum is defined via the test parameters. Drive update is performed as the following three steps:

- a. An updated exponentially averaged control spectrum $|C_E|_N^2$ is formed from the previous exponentially averaged control spectrum $|C_E|_{N-1}^2$ and the new control spectrum $|C|_N^2$:

$$|C_E|_N^2 = (1 - 1/P) |C_E|_{N-1}^2 + (1/P) |C|_N^2$$

Note the discount averaging used. The relative amounts of the previous and the new spectra that are included in the updated spectrum depends on $P = 2^K$, where K is a control loop parameter chosen during test setup.

- b. For the first frame, the reference spectrum $|R|^2$ is used as the initial drive spectrum $|D|_N^2$.

For subsequent loops a new, updated drive spectrum $|D|_N^2$ is computed from the exponentially averaged drive spectrum $|D_E|_{N-1}^2$ and the ratio of the reference spectrum $|R|^2$ divided by the updated exponentially averaged control spectrum $|C_E|_N^2$:

$$|D|_N^2 = |D_E|_{N-1}^2 \{ |R|^2 / |C_E|_N^2 \}$$

- c. The updated exponentially averaged drive spectrum $|D_E|_N^2$ is formed from the previous exponentially averaged drive spectrum $|D_E|_{N-1}^2$ and the updated drive spectrum $|D|_N^2$. The updated averaged drive spectrum $|D_E|_N^2$ is used in computing the updated drive spectrum in the next loop. The same discount averaging used for the control spectrum update is also used here:

$$|D_E|_N^2 = (1 - 1/P) |D_E|_{N-1}^2 + (1/P) |D|_N^2$$

2.3.1.7 Complex Fourier Spectrum Generation. The updated drive spectrum $|D|_N^2$ is a PSD function that lacks phase. It is converted to a complex frequency function by the addition of phase information, using a random number generator.

2.3.1.8 Inverse Fourier Transform. The complex drive spectrum is next converted to a (real) drive signal frame D_N via the inverse FFT algorithm:

$$x(t_i) = \sum_{K=0}^{(M/2)-1} X(f_k) \exp(j2\pi i k/M)$$

where $i = 0, 1, 2, \dots, N-1$.

2.3.1.9 Time Randomizing and Tapering. This step completes the loop. The updated drive signal D_N is repeatedly randomized, tapered, and sent to the D/A converter during the next loop. At the end of the next loop another updated drive spectrum D_{N+1} replaces D_N . This process continues as long as the test is active.

Although the same drive signal is used repeatedly throughout one loop, the frames sent to the D/A are not identical due to the randomization process. Randomization consists of using a random number generator to select a new (random) start point in the drive frame, for each frame output. This ensures that the drive signal provides true random excitation of the external load.

Tapering is a shaping process applied to each drive frame. It includes a windowing and frame overlap process that eliminates discontinuities between successive drive frames, while maintaining the correct total energy in each frame.

2.3.2 Loop Timing Diagram

The time required by the RANDOM program to execute the control loop is called the loop response time or the loop time. This time is divided into time periods of length T . The quantity T represents the time required to acquire one frame of input data (see paragraph 2.2.1). This same quantity is also the time required to output one drive signal frame; signal input and drive output go on simultaneously and are synchronized.

Figure 2-4 timing diagram shows how the loop time is divided among the operations comprising the loop. The loop shown in Figure 2-4 has one control channel. It also has $N=4$, which means that within each loop four input frames are acquired from the control channel during each loop. The analog/digital and digital/analog conversion operations are denoted respectively by A/D and D/A. Two memory buffers are provided for each of the A/D and D/A operations. Frames are input and output alternately from buffer 1 and buffer 2, and the resulting processes are called A/D₁ and A/D₂ (for input) and D/A₁ and D/A₂ (for output). These are direct memory access (DMA) processes that can take place concurrently with other processor operations. Note, however, that the other operations in the loop (randomization and tapering, FFT/PSD calculations, drive signal update and generation, and the production of a display on the system CRT) are all processor operations and must be performed sequentially.

The continuous output of a drive spectrum during the loop takes priority over all other operations. Therefore during each time period T the first operations performed are the output of a tapered drive signal to the D/A convertor and the randomization and tapering of a drive signal frame in preparation for the next period.

The acquisition of input frames goes on concurrently with drive signal output. At the start of the loop both input memory buffers are assumed available, and a frame is acquired into one of these buffers during each of the first two periods of the loop. As soon as a frame is acquired FFT and PSD calculations on the frame are begun (but note that this processing is not begun in each period until the randomization and tapering operation is completed). When these calculations are finished the buffer is available to contain another input frame, and a new frame is acquired during the following period. This continues until $N=4$ frames are acquired.

Note: In Figure 2-4, the time to perform the FFT and PSD calculations is shown as greater than the frame acquisition period T . This causes gaps to occur between the acquisition of input frames; i.e., there are some periods when no data is being acquired. If the FFT/PSD time is not greater than T , then data acquisition is performed without gaps and the acquisition is termed realtime.

As soon as $N=4$ input frames are acquired and processed, generation of an updated drive spectrum can be performed (but with priority given to randomizing at the start of each period). Following the completion of an updated drive signal a CRT display is generated. When display generation is accomplished the loop is over. The first time period T following the completion of the display task marks the start of the next loop. The signal output to the D/A is then the updated drive signal, and data acquisition occurs again.

Note that the presence of the display task extends the loop time. If you inhibit the display, the loop time is reduced. This allows more loops per unit time, more frequent drive updates, and hence faster equalization.

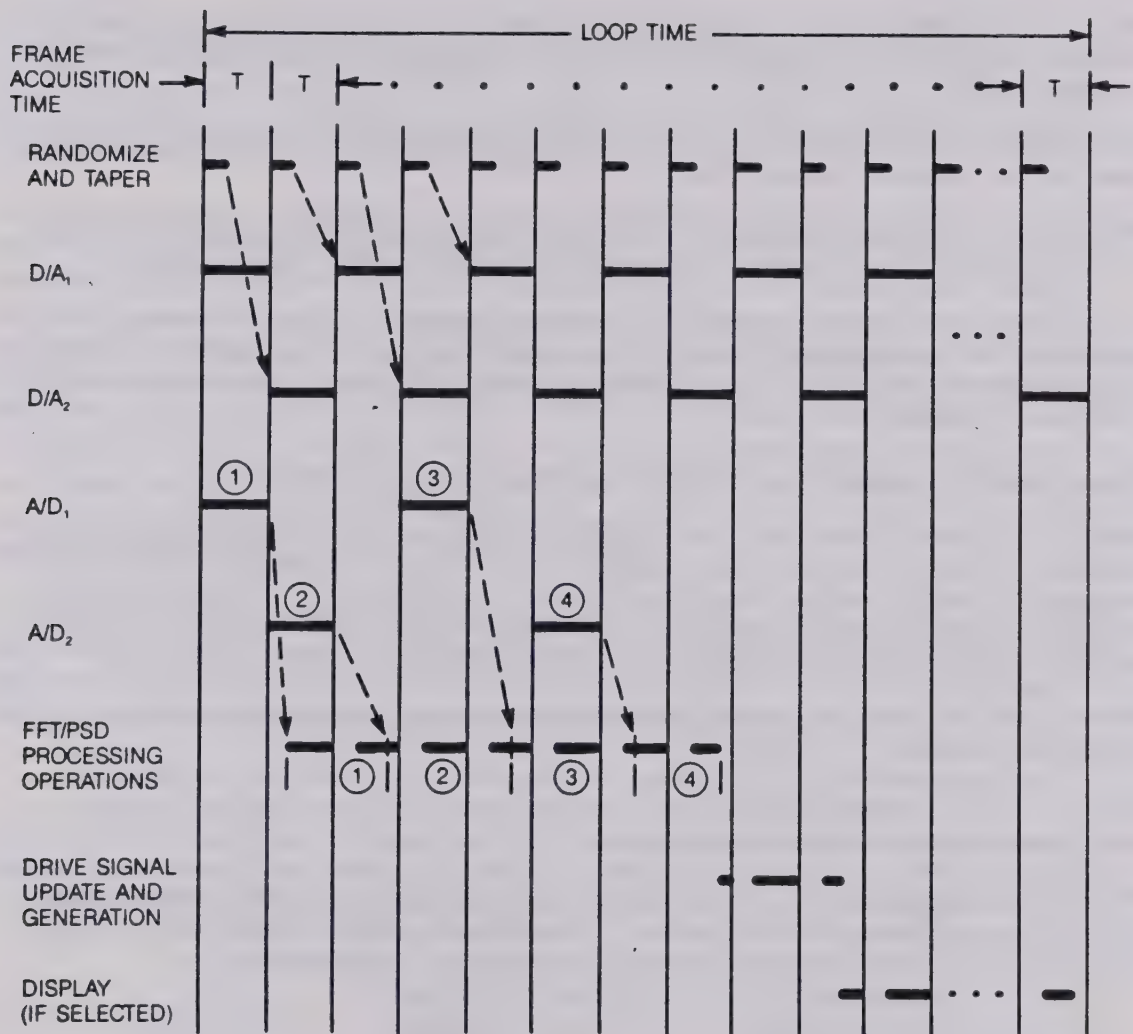


Figure 2-4. Typical Loop Timing Diagram with N=4 and Display Selected

2.3.3 Units

The units associated with the data as it is manipulated within the control loop are shown in Figure 2-3.

Output from each sensor on the external load is a voltage (V) proportional to acceleration. The units of each digitized value in a time signal input frame is likewise volts.

The values in the complex frequency function resulting from the Fourier transform have units of volts per Hertz (V/Hz).

The values of a spectrum (PSD), have units of volts-squared per Hertz (V^2/Hz). Drive comparison and update are performed using spectra with V^2/Hz values.

In producing a new drive signal the preceding sequence of units is reversed. The drive PSD (V^2/Hz) becomes a complex frequency function (V/Hz) and then a frame of time signal information (V). The analog drive signal output to the external load is likewise a voltage (V).

Two other units are used in operations involving spectra: mV and grms.

When a spectrum is selected for display, the accelerometer sensitivities (mV/g) entered as test parameters are applied to the spectral values for the control, auxiliary, monitor, and reference spectra (see paragraph 2.4). The sensitivity factors are used to convert the spectrum values from $(mV)^2/Hz$ to g^2/Hz , and they appear in g^2/Hz (for linear scaling) or dB (for log scaling) on the CRT display.

There is no accelerometer associated with the drive signal, so the drive spectrum is displayed in units of $(mV)^2/Hz$.

The error and transmissibility spectra (see paragraph 2.4) are defined as ratios of other spectra and are therefore unitless.

The overall magnitude or level of a spectrum is computed in g root-mean-squared (grms) of the individual spectral values. If a spectrum consists of J values m_i (where $i = 1, 2, 3, \dots, J$), then the grms value of the spectrum is calculated as

$$\text{grms} = \sqrt{\sum_{i=1}^J \{(m_i)(\Delta f)\}}$$

where the m_i have units of V^2/Hz and an accelerometer sensitivity (in mV/g) is used to convert voltage to g.

2.3.4 Spectrum Averaging in the Control Loop

Averaging of the control spectra is performed at three places in the control loop. Averaging of the drive, monitor, and auxiliary spectra take place once each in the loop. These averaging processes are described individually in the following subparagraphs.

2.3.4.1 Linear Time-Averaging of Each Control Channel. During each loop execution N frames of data are acquired for each control channel in steps (3), (4), and (5) of the loop (see paragraph 2.3.1 and Figure 2-3), and a separate PSD is calculated from each frame. The N PSD's for each channel are linearly averaged together to form one averaged PSD per control channel.

2.3.4.2 Composite Averaging of Control Channels. If more than one control channel is specified, the single-channel, linearly averaged PSD's are averaged together to form the new control spectrum $|C|_N^2$ in step (5) of the loop. If there is only one control channel, the linearly-averaged PSD for that channel is already the new control spectrum. There is a choice of averaging algorithm: linear averaging is the default choice, but extremal control is selectable via the test parameters as an alternate averaging type. With linear averaging the contribution from each single-channel PSD to $|C|_N^2$ is equal. With extremal control averaging, the value used for each spectral line in $|C|_N^2$ is the maximum of the values for that line from the various single-channel PSD's. Extremal averaging produces a drive spectrum of somewhat lower level than does linear averaging.

2.3.4.3 Update Averaging of Control and Drive Spectra. This type of averaging is performed in step (6) of the control loop in the formation of the updated control spectrum $|C_E|_N^2$ and the updated drive spectrum $|D_E|_N^2$. The averaging algorithm used is called exponential averaging or discount averaging, and operates as follows:

$$\text{updated spectrum} = (1-1/P)(\text{previous spectrum}) + (1/P)(\text{new spectrum})$$

where $P=2^K$ is the discount factor and K is a selectable control loop parameter. The choice of K causes the updated spectrum to be comprised of different fractions of the previous spectrum and the new spectrum, as shown in the following table.

K	P=2 ^K	Fraction of Previous Spectrum (1-1/P)	Fraction of New Spectrum (1/P)
0	1	0	1
1	2	1/2	1/2
2	4	3/4	1/4
3	8	7/8	1/8
4	16	15/16	1/16

Note: If the number of spectra updated (n) is much greater than P , then the number of degrees of freedom of an updated spectrum formed by discount averaging can be shown to be:

$$\text{DOF} = 2N(2^{K+1}-1) = 2N(2P-1)$$

2.3.4.4 Auxiliary/Monitor Spectrum Averaging. The auxiliary and monitor spectra are defined in paragraphs 2.4.3 and 2.4.4. These spectra can be averaged separately from the control and drive spectra. A separate and distinct set of averaging parameters is provided for the auxiliary and monitor spectra, where you may select and change these parameters during a test. Linear and exponential averaging are available; the characteristics of each averaging type are given below.

- a. **Linear averaging.** All spectra input to the system (N per loop) are linearly averaged together until the selected maximum number of spectra are accumulated. The maximum values selectable are 1,2,4,8, . . . , 1024,2048, and ALL. If ALL is selected the averaging process continues indefinitely. You can re-initialize the averaging process at any time (by pressing the keyboard RESET key).
- b. **Exponential averaging.** This averaging is the same as the update averaging for the control and drive spectra, except that the discount factor used is not P but a separate parameter that you can select and change while a test is in progress.

2.3.5 Loop Response Times

The control loop time depends on a number of program parameters, including the bandwidth (B) and resolution of the spectra calculated, the number of control channels, the number of frames of data acquired per channel each loop (N), whether or not the display is selected, and whether or not an auxiliary channel is defined. The following table shows loop response times for a number of typical combinations of parameter values. The test conditions in effect for these loop times are: one control channel, no auxiliary channel, display off, and no drive signal clipping.

Bandwidth (Hertz)	Resolution (No. of Lines)	Frames per Loop (N)	Loop Time (seconds)	
			LSI 11/2	LSI 11/23
2000	100	1	1.2	.8
2000	200	1	2.2	1.5
2000	200	2	2.3	1.6
2000	200	4	2.4	1.8
2000	200	8	2.8	2.2
2000	200	16	3.7	3.0
2000	100	4	1.4	1.0
2000	400	4	4.7	3.4
2000	600	4	8.0	5.8
2000	800	4	9.0	6.8
1000	200	4	2.8	2.2
4000	200	4	2.6	1.8
8000	400	4	7.5	5.1

2.4 CHANNEL AND SPECTRUM DEFINITIONS

The various types of channels, signals, and spectra used with the RANDOM vibration program are defined in this paragraph. The term "channel" is used in regard to the hardware involved in the input/output of data. A "signal" refers to the time-domain data, either analog or digital, that is input or output on a channel. A "spectrum" is a digital frequency function (usually a PSD) that has been calculated from a signal via the FFT operation. A spectrum may be averaged (computed from a number of frames of one or more signals) or unaveraged (computed from a single frame). The following table summarizes the types of channels, signals, and spectra that occur in conjunction with the RANDOM program.

Type	Signal	Channel	Spectrum
INPUT	x	x	x
CONTROL	x	x	x
AUXILIARY		x	x
MONITOR			x
REFERENCE			x
ERROR			x
DRIVE/OUTPUT	x	x	x
TRANSMISSIBILITY			x
INVERSE TRANSMISSIBILITY			x

2.4.1 Input

All response data generated by accelerometers attached to the external load and connected to the system's A/D converter constitute the input signals. The individual A/D channels are the input channels via which the data enters the system. The PSD's that are computed from the input signal of each channel are the input spectra. Up to 16 input channels are available via use of the 16-channel selector option.

2.4.2 Control

The control signals are those input signals you select to control the external load. Anywhere from one to all available input signals may be chosen to be control signals. The A/D channels carrying the individual control signals are designated as the control channels. The new control spectrum $|C|_N^2$ is the single PSD function formed by averaging together the PSD's of the individual control channels. The new control spectrum is exponentially averaged with the control spectra from previous loops to form the updated control spectrum $|C_E|_N^2$.

The effect of using multiple control channels in forming the new control spectrum is that response signals from different points on the test specimen are used to equalize the drive signal. Thus, if the specimen has a shape or mass distribution that causes it to respond differently in different areas of its structure, multiple control signals from different points can be used to produce an average response for the specimen as a whole. Note that the RANDOM program allows the same input channel to be designated as two or more control channels, to give extra weight to the response from a single point on the specimen in calculating the control spectrum.

2.4.3 Auxiliary

You may designate any one input channel as an auxiliary channel. The averaged PSD calculated from the data on this channel is the auxiliary spectrum. An input channel can be the auxiliary channel whether or not it is also selected as a control channel. The significance of the auxiliary channel is that its PSD can be computed and displayed separately from the control spectrum, allowing you to inspect the response data from a single point on the test specimen. The accelerometer sensitivity and averaging parameters of the auxiliary channel may be different from the parameters used for the control channels and may be changed during a test. Further, you may select different input channels to be the auxiliary channels during a test, allowing the PSD of each individual input channel to be examined.

2.4.4 Monitor

The monitor spectrum is an averaged PSD computed from the same channels selected as the control channels. However, the averaging parameters used in computing the monitor spectrum are separately selectable and may be changed during a test. The monitor spectrum is maintained separately from the control spectrum and is not used in updating the drive spectrum. The monitor spectrum can be separately displayed to allow you to note the effect of different averaging on the control signals. For example, the monitor averaging discount factor can be selected so that the monitor spectrum consists only of the new PSD's and does not include any contribution from the PSD's of previous loops.

2.4.5 Drive or Output

The drive channel or output channel is the D/A converter, smoothing filter, and other associated hardware of the system that is used to output data to the external load. The drive (or output) signal is the time-domain data D_N output via the drive channel. The drive (or output) spectrum is the PSD function $|D|_N^2$ that results from the equalization process in the control loop.

If you do not specify otherwise, the initial drive spectrum used at the start of a RANDOM vibration test is a scaled copy of the reference spectrum. It is also possible to select a prestored drive spectrum, either a drive spectrum left in memory from a prior test, or a drive spectrum retrieved from disk. This feature is selected by answering the setup question PRESTORED DRIVE? with a Yes.

2.4.6 Transmissibility

The transmissibility spectrum is defined as the ratio of the auxiliary spectrum divided by the monitor spectrum. This quantity may be used to show the difference between the response from the single input channel designated as the auxiliary channel and the response from the control channel(s).

2.4.7 Inverse Transmissibility

The inverse transmissibility spectrum is defined as the ratio of the monitor spectrum divided by the auxiliary spectrum, i.e., it is equal to $(1/\text{transmissibility spectrum})$. Depending on the relative magnitudes of the auxiliary and monitor spectra, the ratio of their values at certain frequencies may be difficult to observe on the CRT display due to the limits of its dynamic range. The inverse form of the transmissibility spectrum is supplied to facilitate examination of out-of-range values of the spectrum.

2.4.8 Error

The error spectrum is defined as the ratio of the monitor spectrum divided by the reference spectrum. This spectrum gives an indication of the extent to which equalization has been achieved.

2.4.9 Reference

The reference spectrum describes the distribution of energy with frequency to which the test specimen shall be excited. The frequency range of the reference spectrum is from 0 (Hz) to a specified maximum frequency B (in Hz), where B is called the control bandwidth. Energy values are expressed in units of g^2/Hz .

The reference spectrum is defined using your entered parameters as a number of pairs of frequency and energy level values (where each pair of values is called a breakpoint) plus an initial slope from 0 Hz to the first breakpoint and a final slope from the last breakpoint to the control bandwidth.

The program automatically completes the spectrum by connecting adjacent breakpoints. In addition to the reference spectrum itself, tolerance limits may be defined surrounding the spectrum as a safety feature (see paragraph 2.6.3). A typical reference spectrum is shown in Figure 2-5. The program allows a maximum of 40 breakpoints to describe the reference spectrum.

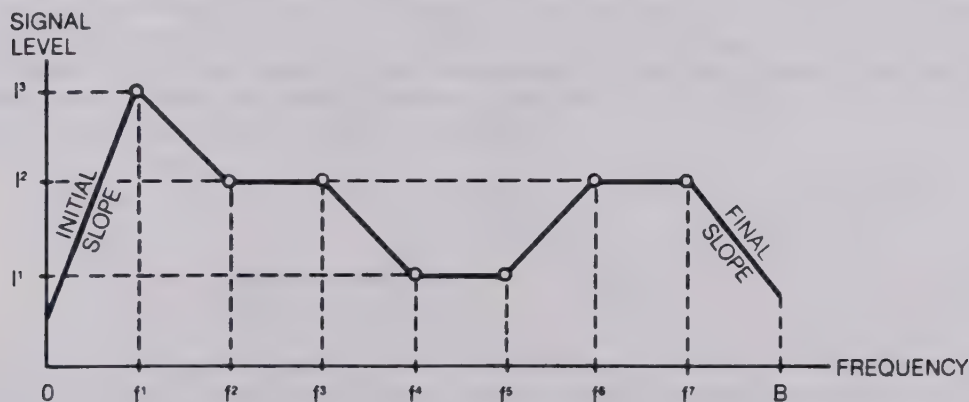


Figure 2-5. Typical Reference Spectrum

There are two ways of specifying a breakpoint. The first method is to explicitly supply a frequency and a level. In this case each breakpoint is independent of the adjacent breakpoints; when a breakpoint is defined the program automatically connects it to the previous breakpoint by a straight line segment.

The second method of breakpoint definition is to specify a slope (in dB/octave) instead of a frequency and level. In this type of definition the actual location of the breakpoint is dependent on both the previous and the next breakpoint. The breakpoint frequency is computed by the program and is called the cross-over frequency. The level of the breakpoint is the same level as the previous breakpoint.

A limitation imposed on the use of breakpoint definition by means of slope, is that two consecutive slope-type breakpoints are not allowed. This means that the breakpoints adjacent to a slope-form breakpoint must be of the frequency-and-level type. (This rule includes the initial and final slopes of the reference spectrum, so that the first and last breakpoints, which are respectively adjacent to these slopes, must be supplied in frequency-and-level form.)

The procedure for defining a slope-type breakpoint is shown in Figure 2-6. If the breakpoint parameter values supplied for a slope-type breakpoint do not correctly define a cross-over frequency, the program does not define the breakpoint but gives you the option to redefine the three breakpoints involved in the process.

An alternate means of reference spectrum definition is provided that allows use of a spectrum that was generated from experimental data. This is called the control to measured PSD capability and is performed as follows:

The test function or open-loop analysis function is executed and the desired spectrum is calculated as the monitor spectrum. At the conclusion of the test or analysis function the setup function is executed, and the parameters plus current spectra are stored on disk to save the desired spectrum for later use. To make use of this spectrum as the initial reference spectrum for a subsequent test, the file containing the parameters plus the spectrum is retrieved from disk as a setup function choice, and the setup question MOVE MONITOR PSD TO REFERENCE? is answered Yes.

1. Defines the prior breakpoint in frequency-level form via the setup function, by specifying its frequency (f_1) and signal level (L_1).

(f_1, L_1)

2. Defines the breakpoint in question as a slope (S_2). The actual location of the breakpoint is not yet established.

A dashed line with a positive slope S_2 originates from the point (f_1, L_1) .

3. Defines the next breakpoint in frequency-level form by specifying its frequency (f_3) and level (L_3). (Note: if L_3 is less than L_1 , then slope S_2 must be negative.)

A dashed line with a positive slope S_2 passes through the points (f_1, L_1) and (f_3, L_3) .

4. Program constructs a horizontal line from (f_1, L_1) in the direction of increasing frequency, and a line of slope (S_2) intersecting (f_3, L_3) and extending in the direction of decreasing frequency.

A horizontal line segment starts at (f_1, L_1) and extends to the right. A dashed line with a positive slope S_2 intersects this horizontal line at the point (f_3, L_3) .

5. Program then defines the breakpoint in question as the intersection of the two lines constructed in step 4. The level of the breakpoint is L_1 , the same level as the prior breakpoint. The frequency of the breakpoint is the cross-over frequency f_2 determined by the intersection of the two lines. The reference spectrum is then completed between frequencies f_1 and f_3 by connecting the three breakpoints with straight line segments.

The completed reference spectrum consists of three points connected by straight line segments: (f_1, L_1) , (f_2, L_1) , and (f_3, L_3) . The segment from (f_1, L_1) to (f_2, L_1) is horizontal, and the segment from (f_2, L_1) to (f_3, L_3) has a positive slope.

Figure 2-6. Determination of Frequency and Level of a Slope-Type Breakpoint

2.5 SPECTRUM EQUALIZATION

2.5.1 The Equalization Process: Accuracy, Speed, and Variance

During a test, the system performs equalization by sending a drive signal to the external load. The drive signal results in control signal(s) that produce a PSD. The PSD conforms to the specified reference spectrum. It requires several executions of the control loop to achieve equalization. During this time, both the drive signal and the control signal(s) are changing. After equalization is achieved, significant changes to the drive and control signals should not occur as long as the total energy or level of the drive signal remains constant. However, during a typical test the level of the drive signal changes in a specified fashion (see paragraph 2.7). When a change in the drive level occurs, the relative amplitudes of the resonances excited in the external load in general also change. This changes the shape of the control spectrum produced, and de-equalizes the control loop to a certain extent. The updated drive spectrum starts to compensate for this change as the test progresses. Equalization is thus a continuous process throughout the test.

Three characteristics of the equalization process are measures of its performance. These characteristics are control accuracy, equalization speed (or rate), and variance. Control accuracy indicates how closely the control spectrum can be made to conform to the reference spectrum. The accuracy depends on the number of degrees of freedom (DOF) the number of frequency lines in the control spectrum, and the control bandwidth. Equalization speed is the time required to achieve equalization, and is a function of the number of loops that must be executed before equalization occurs, and of the loop time. Variance is a measure of the smoothness of the equalization process, and depends on the amount that the drive signal can change from one loop to the next.

Ideally, equalization could be attained very quickly with a smooth transition of updated drive signal values, and could result in a very close match between the control and reference spectra. In actual practice equalization cannot be simultaneously quick, smooth, and accurate. A trade-off among these characteristics is required as is shown in the next paragraph.

Note: Use of the prestored drive capability (paragraph 2.4.6), where a retrieved drive spectrum that produced equalization on the same or a similar external load, results in fast initial equalization without compromising accuracy or smoothness.

2.5.2 Equalization Parameters

The following four program parameters govern equalization performance. You can specify all of these parameters.

2.5.2.1 N. Number of frames required per input channel per control loop. See paragraph 2.3.4, linear time averaging of each control channel.

Increasing N increases the DOF of the PSD's and therefore increases control accuracy and smoothness. However, increasing N also increases the loop time and therefore decreases equalization speed. When the RANDOM program is loaded this parameter has an initial value of N=4. This value is adequate, unless the input signals are noisy or variable so that additional averaging is required to reduce the variance of the control spectra. On the other hand, if the input signals have low

noise and are time stationary or almost so, N may be decreased to lower the loop time and achieve faster control.

2.5.2.2 K . Discount exponent used in the spectrum update process. The quantity K is not used directly; instead, the discount factor $P=2^K$ is used in the spectrum update equations (see paragraphs 2.3.1 and 2.3.4).

Increasing K decreases the portion of the new spectrum used in the update process. This improves the equalization variance (smoothness), but decreases the rate at which the control loop can respond to changes in the response from the external load and hence decreases the speed of equalization. This parameter has an initial load time value of $K=3$. The table in paragraph 2.3.4 shows that if K exceeds 3 almost none of the new spectrum is included. For this reason larger values of K are rarely used. If the input signals are largely time-stationary, however, K may be decreased to increase equalization speed.

2.5.2.3 M_f . Number of frequency lines in the spectra of the control loop. M_f is equal to $M/2$, where M is the number of points in the input and drive signal frames (see paragraphs 2.2.1 and 2.2.4).

Increasing the value of M_f improves the frequency resolution of the spectra and thereby increases the control accuracy. This also, however, increases the time to acquire and output the signal frames and therefore increases the loop time and lowers the equalization speed.

2.5.2.4 B . Control Bandwidth. This is the highest frequency present in the input and drive spectra, and thus the highest frequency for which the external load is controlled.

The control bandwidth is usually mandated by the vibration test specification that is to be followed in testing a device or structure. In such cases you cannot choose a control bandwidth. If, however, you are free to select the control bandwidth, the effects are as follows: increasing B decreases the loop time, giving increased equalization speed; but increases the frequency resolution, giving decreased control accuracy.

Therefore, changing any of the equalization parameters to improve one characteristic of equalization performance degrades another performance characteristic. You must therefore make an optimum selection of parameter values for a trade-off among accuracy, speed, and smoothness of equalization. The following table summarizes the effects of the parameters on equalization performance.

Change	Parameter	Accuracy	Speed	Variance/Smoothness
INCREASE	N	BETTER	SLOWER	BETTER
DECREASE	N	WORSE	FASTER	WORSE
INCREASE	K	-	SLOWER	BETTER
DECREASE	K	-	FASTER	WORSE
INCREASE	M_f	BETTER	SLOWER	-
DECREASE	M_f	WORSE	FASTER	-
INCREASE	B	WORSE	FASTER	-
DECREASE	B	BETTER	SLOWER	-

2.5.3 Drive Update Enable/Disable and Reference Spectrum Modification

The RANDOM program includes two additional equalization capabilities and are discussed in the following sub-paragraphs.

These features are available only when the test function is in manual mode (see paragraph 2.7.3).

2.5.3.1 Drive Update Enable/Disable. During typical operation of the test function the equalization process results in update of the drive spectrum $|D|_N^2$ once per loop. In this type of operation the drive update is enabled. However, you can disable update of the drive spectrum via the DRIVE UPDATE menu parameter (see paragraph 3-2). While drive update is disabled, equalization is inhibited. In this case the drive signal continues to be output to the external load but does not change in frequency content. Randomization and tapering of drive signal frames continue, and all active safety features of the program remain in effect while drive update is disabled. No control spectrum is computed while drive update is disabled, but the monitor spectrum is available for observation of the system response. The same DRIVE UPDATE menu parameter is used to re-enable drive update.

Disabling drive update can be useful to allow you to observe the effect on the test specimen of a particular drive signal.

2.5.3.2 Reference Spectrum Modification. This feature allows you to insert changes to the reference spectrum during a running test or in standby. As soon as such a change takes effect the program begins to equalize to the altered reference spectrum and the effect can be observed on the CRT spectrum display. This capability is useful in accommodating a resonance or anti-resonance in the external load or the presence of extraneous signals (such as 50 Hz or 60 Hz noise) in the control loop. It can also be used to construct a reference spectrum that requires more than 40 breakpoints, the maximum allowed by the program.

This capability is accessed via the MODIFY special function key and Test Modification menu parameter (see paragraphs 3-2 and 3.5.6.1). If the reference spectrum is stored on disk (paragraph 2.12.4) the stored spectrum includes all modifications. However, these modifications are not included in the setup parameters within the program. These parameters will still define the unmodified reference spectrum.

Note that the abort limits safety feature (see paragraph 2.13.3) is not active while the reference spectrum is being modified during a test.

2.6 TEST LEVEL CONTROL

The level of a test is the overall grms level of a frame of the drive signal. The drive signal level changes by several orders of magnitude during a test, from the very low levels used during the pre-test loop check to the maximum test level that is based on the definition of the reference spectrum. Control of the drive signal level deals with the strategies provided by the RANDOM program to vary the drive signal level in a systematic fashion throughout the test.

The variability of the drive signal level is much greater than that of the frequency content of the drive signal. The drive signals output to the external load during a test include frequencies over the entire control bandwidth range (0 - B Hz). The shape of the drive spectrum describes how the energy of the signal is distributed among the frequencies it contains. As previously stated, when the external load is equalized the shape (or energy versus frequency distribution) of the drive spectrum results in a control spectrum that matches closely the energy distribution (shape) of the reference spectrum. Throughout the test this energy versus frequency distribution does not change greatly as long as equalization is maintained.

Figure 2-7 illustrates the energy versus frequency (shape) and energy versus time (level control) dependence of the drive spectrum $|D|_N^2$ during a test while equalization is maintained. The basic shape of the spectrum does not change with time, but its level (energy) does. If you look only at the energy and frequency axes (arrow 1) the diagram shows the shape of the reference spectrum on which equalization depends (see also Figure 2-5). Looking only at the energy and time axes (arrow 2) shows the changing level of the drive spectrum during the test. The specification of how the drive level is to change throughout the test represents level control of the drive signal.

The RANDOM program provides three different schemes for control of the drive signal level. These are unscheduled level control and two kinds of level scheduling, called level profile and level cycles. For each of these kinds of level control the energy versus time diagram for a test is divided into three areas: a loop check, the test itself (either unscheduled or scheduled), and test shut-down.

In the test area, the drive signal level normally is above the test low level you selected as a setup parameter, and below the test full level (or maximum level) determined from the reference spectrum. The time spent in the test area consists of an initial period with the drive at low level, followed by the remainder of the test period during which time the level varies between low level and full level in an orderly fashion that depends on the type of level control in effect. Equalization of the external load is first achieved during the time at low level, and is maintained thereafter while the drive level changes.

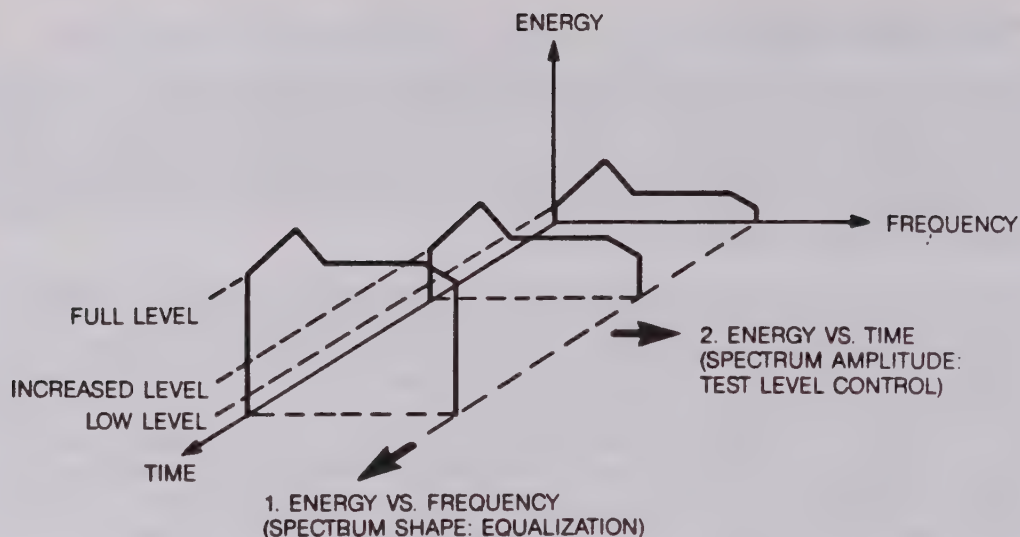


Figure 2-7. Spectrum Frequency vs. Energy vs. Time Diagram

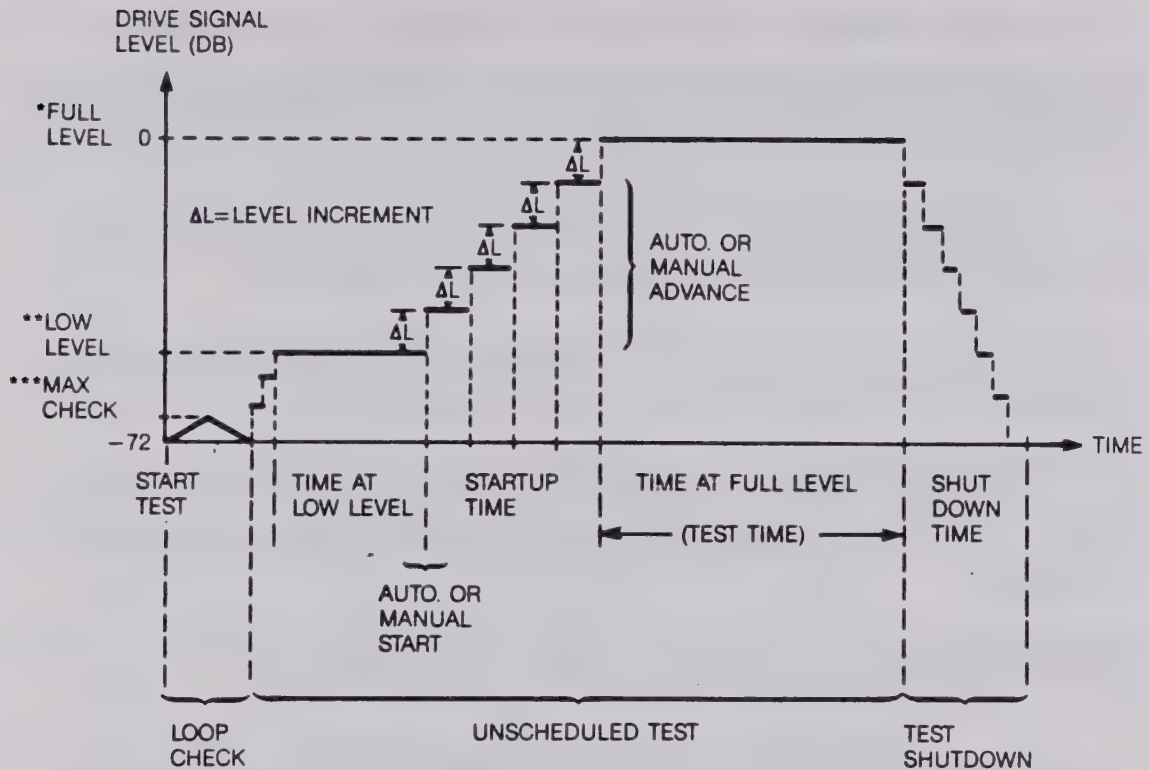
2.6.1 Unscheduled Level Control

Unscheduled level control is the default control scheme that is used if level scheduling is not specifically selected as a setup parameter. The drive level diagram for a test using unscheduled control is shown in Figure 2-8.

A test with unscheduled control has the following characteristics: after the loop check is completed the drive level increases to the low level defined for the test, stays there for a time (during which equalization takes place), and then increases in level increment steps ΔL from low level to full level. The duration of the increase is the test startup time. The test remains at full level until the specified test time has elapsed, and then shuts down by decreasing to -30 dB. The duration of shutdown is specified as the test shutdown time.

The drive signal may leave low level and may increase from low to full level either automatically (under program control) or manually (under direct operator control), depending on whether manual or automatic start and increase was selected for the test. For details see paragraph 2.6.2.

The drive level shown in Figure 2-8 assumes that the test goes to completion and terminates normally. In practice the test can be aborted at any time, either by your actions or via one of the automatic safety features.



- * Full (maximum) level is defined as 0 dB. The control program calculates the grms level associated with full level from the definition of the reference spectrum. The grms level is printed during execution of the test setup function.
- ** You explicitly specify low level during test setup.
- *** The dB and grms values for this level are computed from the volts value for the loop check maximum drive that you entered as a test setup parameter.

Figure 2-8. Drive Level Diagram, Unscheduled Level Control

2.6.2 Startup Control and Level Increase and Decrease

The RANDOM program includes three additional features that affect control of the drive signal level: manual or auto start, manual or auto drive advance, and level decrease.

2.6.2.1 Manual or Auto Start. This pertains to the method of leaving low level and beginning test startup. Selection is made via a test setup parameter. This feature is available in both manual and automatic mode (see paragraph 2.6.3).

In manual start, the time at low level is not preset. The drive remains at low level until you press the up-arrow key ($\uparrow$). This manual action initiates test startup and causes the drive to increase to the first level increment.

In auto start, the low level time setup parameter is active. In this case no operator input is required to initiate test startup; after the specified time at low level has elapsed the drive signal automatically leaves low level and increases one level increment. The $\uparrow$ key may be used to manually start the test before the low level time elapses.

Subsequent increases in drive level for either manual or auto start depend on the type of level increase selected, as described in subparagraph 2.6.2.2.

2.6.2.2 Manual or Auto Drive Advance. This feature has to do with increasing the drive signal in test startup by level increments of ΔL toward full level. Selection is via the mode menu parameter (see paragraph 3.2). Specifying manual or automatic mode (see paragraph 2.6.3) selects manual advance or auto advance, respectively.

In manual advance the test startup time value is not preset. The drive signal remains at each incremental level until you press the up-arrow key ($\uparrow$) to advance it to the next level.

With auto advance the test startup time setup parameter is active. After leaving low level the drive level increases automatically, spending an equal time at each incremental level, until full level is reached. The time spent at each incremental level is the specified startup time divided by the number of levels.

2.6.2.3 Level Decrease. This capability is available in manual mode only. The level decrease feature allows you to manually decrease the drive signal level while the test is at low level, startup, or full level. This is accomplished by pressing the down-arrow key ($\downarrow$) which decreases the drive level by increments of ΔL . Pressing the up-arrow key ($\uparrow$) increases the drive and reverses the effect of level decrease.

2.6.3 Manual and Automatic Modes

As noted above in paragraph 2.6.2, you select manual or auto start as a setup function parameter, while auto or manual advance is selected via a menu parameter. The mode menu parameter is used to select manual or automatic mode, where automatic mode includes the auto advance feature. A summary of the program features associated with each of the manual and automatic modes is given below.

Manual Mode

- o Either manual or auto start is available.
- o Manual drive decrease is available.
- o Only manual advance is available. The startup time parameter is not active.
- o Drive update enable/disable (paragraph 2.5.3) is available.
- o Reference spectrum modification (paragraph 2.5.3) is available.
- o Manual mode is not allowed with level scheduling (level profile and level cycles).
- o Manual mode is not allowed with test scheduling (paragraph 2.7).
- o The abort limits safety features is active except after the reference spectrum is modified during a test.

Automatic Mode

- o Either manual or auto start is available.
- o Manual drive decrease is not available.
- o Only auto advance is available; the startup time parameter is active.
- o Drive update enable/disable is not available.
- o Reference spectrum modification is not available.
- o Level scheduling forces automatic mode.
- o Test scheduling forces automatic mode.

2.6.4 Level Profile

The level profile feature is selected in the test setup function by first selecting level scheduling and then level profile. You may enter up to 32 drive signal levels (L_i) plus the time (t_i) to remain at each level. No level may exceed the maximum drive level. For a level profile operation, drive update is only active between a drive level range of 0 dB (full level) and -20 dB. This means that if the drive level decreases to less than -20 dB the drive signal is no longer updated (though it is continually randomized, tapered, and output). It is done because accurate control is not possible at low signal levels less than -20 dB. Drive update is resumed when the level rises above -20 dB.

After leaving low level the level profile feature takes effect as shown in Figure 2-9. The test proceeds automatically through the profile, spending time t_i at each level L_i until the last level is completed, whereupon shut down occurs. If the number of loops entered is greater than one, shut down does not occur until all loops are completed.

The transition between successive levels L_i and L_{i+1} is not instantaneous but occurs in steps of ΔL (level increment). In the transition only one drive frame is output at each intermediate level between L_i and L_{i+1} .

Automatic mode is forced on if level profiling is selected. Either manual or auto start may be selected.

For details regarding entry of the level profile setup parameters see paragraph 3.3.4.22.

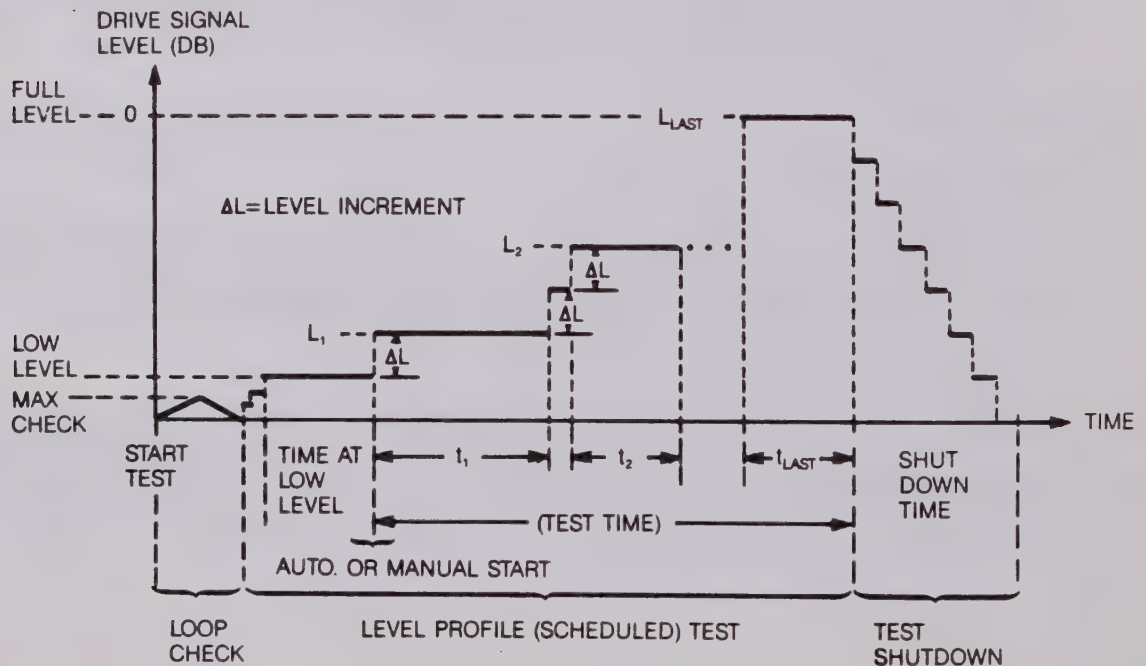


Figure 2-9. Drive Level Diagram, Level Profile

2.6.5 Level Cycles

Level cycles feature is selected in test setup by first selecting level scheduling and then level cycles. You next define a test cycle and the number of times the cycle is to be repeated in the test. A test cycle is defined by the following parameters:

- o Cycle low level, in dB.
- o Decay time from full level to cycle low level (t_1)
- o Time at cycle low level (t_2)
- o Rise time to full level (t_3)
- o Time at full level (t_4)

The level cycles type of level scheduling includes a complete unscheduled test. The cycles are performed only after the unscheduled test is completed. This is shown in Figure 2-10.

As in the case of level profile, drive update is only active between 0 dB and -20 dB. If the drive level falls below -20 dB the drive signal continues to be output but is no longer updated; update resumes when the drive level rises above -20 dB.

Automatic mode will be forced on if level cycles is selected. However, either manual or auto start is available.

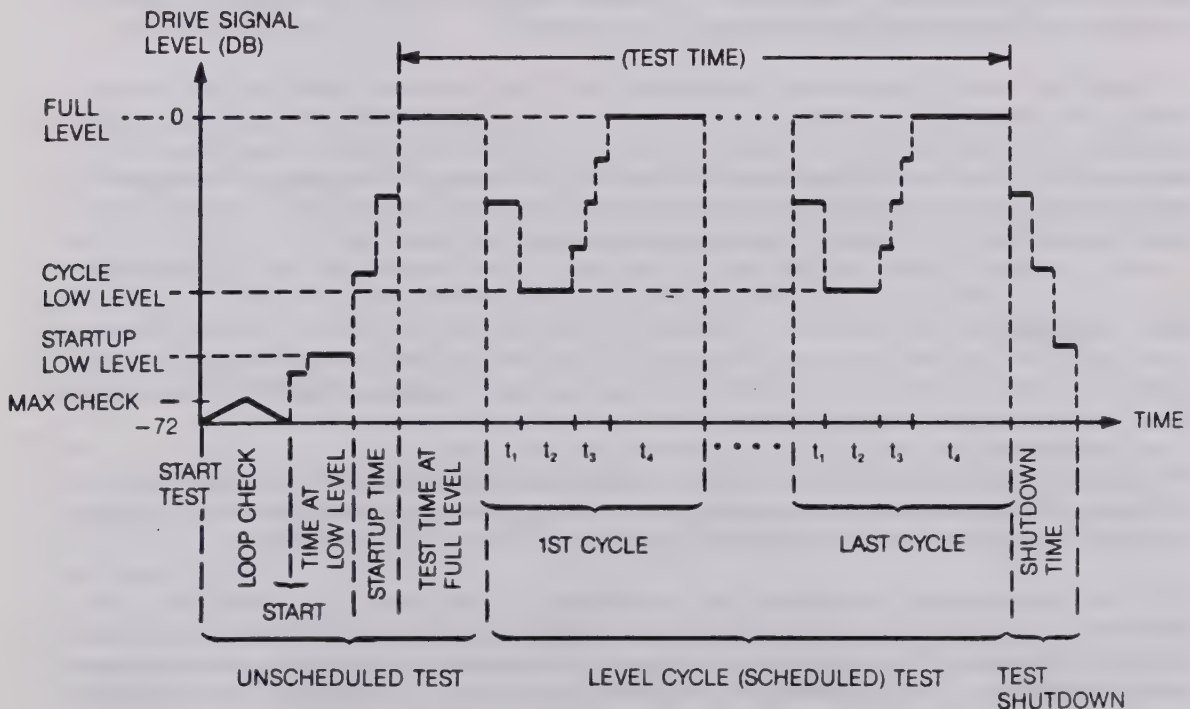


Figure 2-10. Drive Level Diagram, Level Cycles

2.7 TEST SCHEDULING

2.7.1 Test Schedule

The RANDOM program allows you to select a test schedule of up to 63 separate tests, to be run automatically and in a particular order. A schedule consists of a list of names of setup parameter files, where each setup file specifies a test to be run. A typical schedule has the following form:

SEQ. NO.	FILENAME
1	TEST3
2	TEST10
3	TEST5
:	:
:	:
63	TEST85

The schedule also contains information indicating whether local or remote control is selected, and whether the schedule is to be executed in non-repeat or repeat mode. See paragraph 3.9 for setup details.

A test schedule is built and manipulated as part of the setup function. Specifically, the schedule can be created, modified, listed, and retrieved from or stored on disk as a file for future use. A number of different test schedule files may be stored on the same disk by giving them different file names.

Although the setup parameter files named in a test schedule need not be present when the schedule is created, they must be prepared and available when the schedule is executed. The message, FILE NOT FOUND, occurs when there is no parameter file for a scheduled visit. Similarly, although it is possible to create a test schedule and execute it immediately, the usual procedure is to construct the schedule and store it on disk in advance of its use.

2.7.2 Control

Control of the execution of a schedule may be either local or remote, selectable when the schedule is created or modified.

In a remote controlled operation, control of the tests to be executed is exercised via an interface to a remote device such as an environmental control chamber. Details of remote operation are given in paragraph 2.11.

In a local operation all control of the execution of the tests in the schedule is via information contained in the schedule itself. Several options are available for local control of the order of execution of the tests in a schedule. Selection of the options is made when the test schedule is created or modified. The default order is non-repeat execution, which is a single execution of each of the tests in the schedule starting with the first test:

Non-repeat execution: 1, 2, 3, . . . , last-1, last

Two kinds of repeated execution are also provided, named loop and cycle execution. For LOOP execution, a loop is defined as a once only execution of the tests as for the non-repeat case. You can specify the number of times the loop is to be repeated.

Loop execution: 1, 2, 3, . . . , last, 1, 2, 3, . . . last, etc.

With CYCLE execution, a cycle is defined as once up and once back through the tests, i.e., 1, 2, . . . , last-1, last, last-1, . . . , 2, 1. You can select the number of times the cycle is to be repeated.

Cycle execution: 1, 2, . . . , last, . . . , 2, 1, 2, . . . , last, . . . , 2, 1, etc.

The choice of non-repeat or repeat test execution is stored as part of a test schedule. A further capability, the RESUME option, is available to you each time you execute the test. If the resume option is not selected, execution starts with test 1 as shown above. If you select the resume option, you can choose the number of the test to be executed first. If test *n* is selected as the starting point, the order for non-repeat execution is

n, *n*+1, . . . , last-1, last

If repeat execution is selected, the RESUME feature affects only the first loop or cycle. For example, the order for loop execution with RESUME is

n, *n*+1, . . . , last, 1, 2, 3, . . . , last, 1, 2, 3, . . . , last, etc.

2.7.3 Executing a Test Schedule

To execute a test schedule, you must first select the setup function and retrieve the desired schedule file from disk. Modifications to the retrieved schedule may be made at this time. Such modifications include changes to the list of tests, selecting or deselecting remote control, and selecting or deselecting repeat (loop or cycle) execution. You can also verify that all setup files named in the schedule are currently resident on a disk mounted on the system. Modifications apply only to the retrieved copy of the schedule that is in the system memory, and do not alter the contents of the schedule file on disk.

When the schedule has been loaded and any desired modifications are completed, you must exit from the setup function to standby via the 0=EXIT option (see paragraph 3.3.8.1), and then enter the test function. The program automatically selects test scheduling if a schedule is resident in memory, and will list the schedule. You can then start the test.

If remote operation is in effect the tests are executed in an order governed by commands from the remote device. With local control you have the choice of either starting with test 1 or using the RESUME feature to begin with a specific test number.

2.7.4 Automatic Mode

Automatic mode is forced on if test scheduling is selected. This means that when test scheduling is selected the Mode menu parameter (which normally allows choice of manual or auto mode) is ignored and all tests are executed with auto increase (see paragraph 2.6.2).

2.7.5 Test Completion

During execution of a schedule, after each test has shut down a TEST COMPLETED message displays and the next test starts automatically and without your input (except for a test under local control with manual start, for which your action is required to cause a test to leave low level). Following completion of the last test the program returns to standby.

If an abort occurs during any test in the schedule, a warning message displays, the schedule terminates, and the program goes to standby.

2.8 CRT CONTENTS AND FORMAT

2.8.1 Summary of Display Information

The system CRT can contain any of the following six different sets of information during use of the RANDOM program:

SPECTRUM DISPLAY	Default display format for the test, analysis, and data replay function when the display parameter in the menu is not set to OFF. Also the default display in standby state when the menu is not selected. This display format consists of (a) an annotated graticule and spectrum trace, and (b) two lines of summary information appearing above the graticule.
SUMMARY INFORMATION ONLY	Default CRT contents for test, analysis, and standby when the display is OFF.
MENU AND SUMMARY INFORMATION	Occurs while the menu is selected, with the menu replacing the graticule. (See paragraph 3.2 for the menu format.)
SETUP DIALOG	Occurs during execution of the setup function. (See paragraph 3.3.)
POST-TEST MESSAGE	Output produced by the post-test function. (See paragraph 3.6.)
DATA REPLAY DIALOG	Occurs during execution of the data replay function when selection of the spectrum file to be retrieved is taking place. (See paragraph 2.9.6.)
TEST LOG DIALOG	Occurs during execution of the test log function. (See paragraph 3.11.)

2.8.2 Spectrum Display

The general format of the spectrum display is shown in Figure 2-11.

Control over many spectrum display quantities and conditions is available via use of the menu parameter selections. The following list identifies the display conditions that can be modified. The menu parameters that apply to each are given in parentheses. Refer to paragraph 3.2.3 for the full list of selections for each menu parameter.

DISPLAY, STANDARD/OFF	The default condition of the program is the display on and without expansion or display of cursor (STANDARD). The display may be turned off during a test (leaving only the summary information on the CRT) to decrease the loop time.
-----------------------	--

SPECTRUM	Selections are reference, monitor, control, drive, auxiliary, and error spectra, plus the transmissibility and inverse transmissibility functions. The control spectrum displayed is the updated control spectrum $ C_E \frac{2}{N}$.
TOLERANCE BANDS	Default condition is off.
VERTICAL SCALE and MAX VALUE	The maximum Y axis value (item 8 in Figure 2-16) is directly selectable via the MAX VALUE parameter. The vertical axis may be set to linear or log scaling, with a choice of numbers of decades for log scaling. The minimum Y axis value is determined by the program from the maximum Y value and the scaling selected.
HORIZONTAL SCALE	Linear or log scaling is available.
DISPLAY, EXPAND	A portion of the display bounded by your selected frequency range may be expanded to fill the entire display width. This expansion remains in effect until the frequency range is changed or until the display is restored to its standard, unexpanded state.
DISPLAY, CURSORS	When cursoring is selected, two vertical lines are added to the display. The locations of these lines are determined by your responses to the LOWER FREQUENCY and UPPER FREQUENCY program queries that result from requesting the CURSOR LIMIT test modification. See paragraph 2.10.2.7.
CROSS-HATCH	When CROSS-HATCH is selected the tic marks along both axes are extended as dotted lines across the entire graticule, and the AUTO ERASE feature is forced off.
GRAPH	The spectrum data trace can be displayed either as lines (connected points, the default condition) or as unconnected points.
AUTO ERASE	The program default condition is auto erase on. In this state the spectrum trace is erased each time it is redrawn so that only the latest trace displays. If auto erase is turned off the spectrum trace is not erased and successive traces overlay each other.

MONITOR/AUXILIARY AVG, TYPE, PARAMETER

Linear or exponential averaging is available. These parameters apply to both the monitor and auxiliary spectra, and are separate from the averaging conditions for the other spectra.

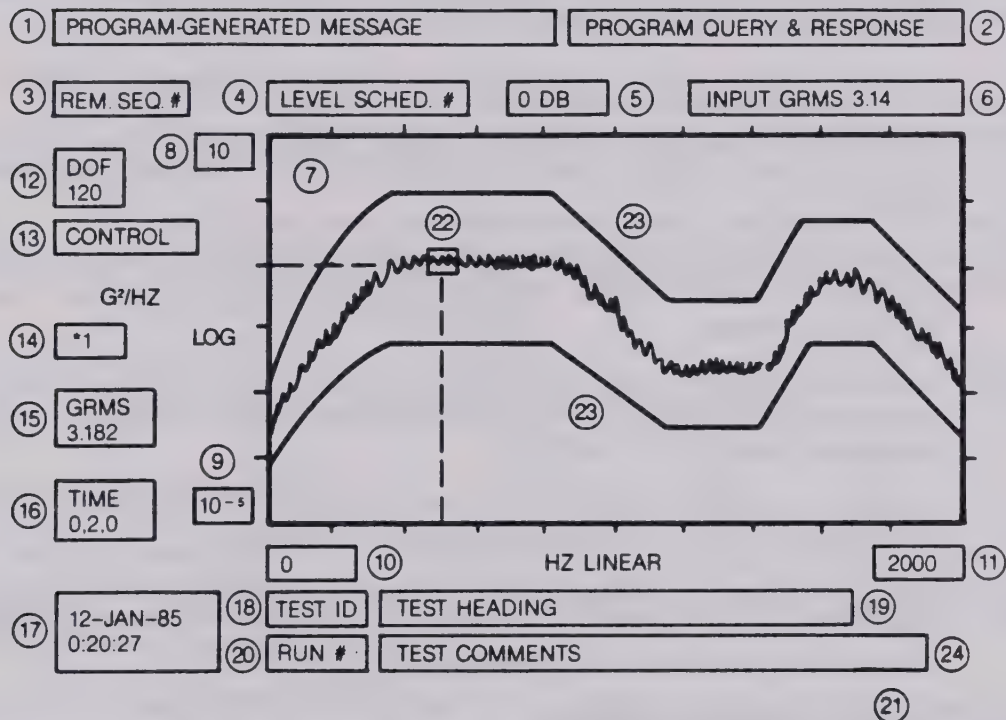


Figure 2-11. Spectrum Display Format

The following are explanations of the numbered items in Figure 2-11.

- Item 1. Message block area where program generated messages display.
- Item 2. Query block area where program generated questions flash and your responses display.
- Item 3. Appears only if test scheduling or remote control (which requires test scheduling) is selected. If test scheduling with local control is in effect, the item is SEQ nn, where nn is the sequence number of the test currently being executed. If test scheduling with remote control is in effect, the item displays as REM SEQ nn.

- Item 4. Appears only if level scheduling is selected. If level profile is selected, the item is Loop m Level n, where m is the loop number and n is the number of the signal level (L_n) currently in effect (see Figure 2-9). If level cycles is selected, the item is CYCLE n, where "n" is the cycle number in effect (see Figure 2-10).
- Item 5. The drive signal dB level relative to full level (0 dB). This item depends on the drive spectrum only, and not on the spectrum currently displayed. Also, on the vertical display axis 1 decade represents 10 dB.
- Item 6. The overall grms level of $|C|_N^2$, the control spectrum for the current loop. If this value is above the alarm grms value, the message ALARM GRMS xx displays in the message block area.
- Item 7. Display graticule with tic marks and horizontal and vertical axis labels.
- Item 8. Maximum vertical axis value. This value depends on the MAX VALUE menu parameters, and changes as the selection of this parameter changes.
- Item 9. Minimum vertical axis value. This value depends on both the VERTICAL SCALE and MAX VALUE menu parameters, and changes as these parameters change.
- Item 10. Minimum horizontal axis value, in Hz. Usually zero for linear, or the frequency resolution Δf for log, but changes if the horizontal display expansion capability is exercised.
- Item 11. Maximum horizontal axis value, in Hz. Usually the control bandwidth, but changes if horizontal display expansion is exercised.
- Item 12. Number of degrees of freedom. This value applies to all spectrum types. The DOF value is calculated as $2N(2P-1)$, where $P=2^K$ and N and K are equalization parameters (see paragraphs 2.3.4 and 2.5.2).
- Item 13. Spectrum type being displayed.
- Item 14. Vertical scale factor used to multiply absolute values of spectral points to generate graph values (item 22). Depends on the current level of the drive spectrum (test level).
- Item 15. The overall grms level of the spectrum being displayed. (If the control spectrum is displayed, this item refers to the grms level of the exponentially averaged control spectrum $|C_E|_N^2$).
- Item 16. Elapsed test time, given in hours, minutes, seconds. This is either the time spent at full drive level (for an unscheduled test) or the time spent at drive levels above test low level (for a test with level scheduling).
- Item 17. Current date and time of day. The time is given in hours:minutes:seconds.
- Item 18. Test ID. Entered as a setup parameter.
- Item 19. Test heading. Entered as a setup parameter.

- Item 20. Appears only during data storage during the test or analysis function, and during the data replay function when a spectrum file is being read and displayed. This item has the form RUN nn, where nn is the run number of the retrieved file testid.Rnn.
- Item 21. Test comments. Entered as a setup parameter.
- Item 22. Spectrum data trace. The absolute value of a point on the trace is determined as follows:
- o Read the value from the graph. For the point indicated on Figure 2-14, the value is 0.1 (two decades down from the maximum vertical value, 10).
 - o Divide the graph value by the vertical scale factor (item 14). In the example of Figure 2-14 the scale factor is 1. The true value of the data point is therefore $0.1/1 = 0.1 \text{ g}^2/\text{Hz}$.
- Item 23. Alarm limits or abort limits tolerance bands. The position of these bands is at your selected dB above and dB below the reference spectrum. The bands appear only if the tolerance bands menu parameter is selected as ALARM or ABORT, respectively.
- Item 24. Test Code. The test code appears only when the test log function has been enabled and a valid test code has been entered.

2.8.3 Display Annotations

You may add annotations to a spectrum display when the system is in standby or in the data replay function, and the spectrum display is present on the CRT. Annotation is not allowed to CRT contents generated during the setup, loop check, test, post-test, or analysis function.

The CTRL/L key combination is used as a toggle switch to enable and disable annotation mode, and the arrow keys are used to specify the CRT location where an annotation is to be made. See paragraph 3.2 for details.

2.9 DATA STORAGE AND RETRIEVAL

Four kinds of information used in the RANDOM program may be stored onto and retrieved from disk during the execution of various program functions. These are setup parameters, test schedules, spectra, and post-test messages. Storage and retrieval of each of these quantities is discussed below.

2.9.1 Storage of Setup Parameters

2.9.1.1 Storage via the Setup Function. Setup parameters are saved as part of the setup function for the purpose of retrieving them for use in subsequent tests, to save the time and possible errors involved in re-entering the parameters from the keyboard. A set of parameters is stored on disk as a file with a filnam.type of testid.RN. You may select the disk device on which the file is stored. The quantity

testid is your test ID setup parameter, and the file type .RN is specified by the program to identify the file as a setup file.

You may elect to store the setup parameters either alone or accompanied by the current menu parameter values and certain spectra (the control, drive, monitor, and auxiliary spectra). The spectra are obtained from the current contents of the spectrum memory buffers at the time parameter storage is selected, and are typically the last spectra remaining in the buffers from the conclusion of the last test or analysis function execution.

Note: Spectra may not be stored along with setup parameters if 600 or 800 lines of resolution is selected (see paragraph 3.3.4.3.).

When storing files on disk the question of duplicate filespecs must be considered. For the case of parameter set files, if testid.RN duplicates the filnam.typ of a file already on the specified device, you can elect either to write over the existing file with the new one or to change the test ID parameter to eliminate the name duplication and retain both existing and new files.

The password that locks the line editor is saved with the parameters and is current when the parameters are recalled from the disk.

2.9.1.2 Test or Analysis Function with Spectra Storage. When the test or analysis function is executed, spectrum storage onto a specified disk unit may be selected for resolutions of 100, 200, or 400 lines (see paragraphs 2.9.4 and 2.9.5).

Note: The program requires that the current setup parameters be stored on the same disk unit. The program searches this disk to determine whether a file with name testid.RN is present. If so, it is assumed that this file is the required setup file and the program proceeds. If not, the program automatically writes the setup parameters from memory onto the disk as the setup file testid.RN, before proceeding.

In this case you are not given the opportunity to write over an existing testid.RN file that is already on the disk. Also, in case the existing setup file on the disk does not contain the same setup parameter values as those currently in memory, subsequent replay of the data could give erroneous results.

2.9.2 Retrieval of Setup Parameters

Retrieval of the testid.RN file containing setup parameters (and optionally menu selections and spectra) is performed as part of the setup function. An error condition may occur when retrieving setup parameters from disk. For example, if a setup parameter file specifying 600 or 800 lines of memory (which require 64K words of memory) are retrieved by a system containing only 32K words of memory, the parameter set cannot be used. In this case the following message displays to alert you of the situation:

NO MEMORY AVAILABLE FOR 600/800 LINES

You must take some action such as changing the resolution in the retrieved parameter set or retrieving another parameter set file before executing a vibration test.

The contents of the file are used for the following three purposes:

In a current test: The setup parameters created for a prior test can be retrieved for use in a current test, avoiding the need to manually re-enter the parameters. The parameters may be used exactly as retrieved, or may be modified after retrieval.

If the file also contains menu parameters and the set of five spectra, these are loaded when the parameters are retrieved and unconditionally replaces any prior menu selections and contents of the corresponding five spectrum memory buffers.

As initial drive spectrum: The stored drive spectrum can be retrieved for use as an initial drive spectrum in a current test. This is done via the prestored drive option (see paragraph 2.4.6) and can be useful in decreasing the equalization time at the beginning of the test.

As reference spectrum: The stored monitor spectrum can be retrieved and used as a reference spectrum, as part of the control to measured PSD option (see 2.4.5). This procedure allows use of a reference spectrum that was derived from experimental data, as an alternative to your definition of the reference spectrum as part of the setup function.

The password that locks the line editor is saved with the parameters and is current when the parameters are recalled from the disk.

Note: A specific file name RANDOM.RN can be saved on the file disk. If this file exists when the program is initially loaded, these setup parameters are automatically read into system memory and are active when the program starts. If there is no file, there is no change from the previous operation.

2.9.3 Storage and Retrieval of Test Schedule

The test scheduling capability of the RANDOM program is described in paragraph 2.7. Included in the capability is the provision to store a test schedule onto disk and retrieve a schedule from disk. A test schedule is stored as a file with filnam.typ of file.RNQ. You may select the disk unit number for storage. The quantity file is the file name you selected in the test scheduling setup dialog and the file type .RNQ is fixed by the program to identify a schedule file. The same notes regarding duplicate filespecs made for setup files also apply to schedule files.

2.9.4 Spectrum Storage During Test Function

The spectra generated during a test function execution may be stored on disk for later use with the data replay function for resolutions of 100, 200, or 400 lines. The stored spectra may be subsequently retrieved and displayed, allowing replay and examination of the test events. The spectra are stored in a file with a filnam.typ of testid.Rmm on your specified disk unit, where testid is the test ID setup parameter and mm is one of 1,2,3,...,99.

Note: If the setup parameter file is not on the operator specified disk, a setup file is created using the current parameters in memory. (See paragraph 2.9.1.2.)

Each execution of the test function is called a run. A maximum of 99 runs may be made with the same test ID in effect. The spectrum files created during these runs have filnam.typ's of

```
testid.R01
testid.R02
.....
testid.R99
```

Each spectrum file consists of a number of records, where each record contains the following quantities:

```
Updated control spectrum  $|C_E|_N^2$  and grms level
Monitor spectrum and grms level
Reference spectrum and grms level
Drive spectrum and grms level
Error spectrum and grms level
Auxiliary spectrum and grms level
Transmissibility and overall level
Inverse transmissibility and overall level
Elapsed time into test
Scale factor
Grms level of new control spectrum  $|C|_N^2$ 
```

These records are written one after another into the file at various times during a test, forming a sequence of spectra that reflect the changing conditions at points throughout the test execution. The test periods during which records are stored depends on whether or not level scheduling (see paragraph 2.6) is in effect. If a test is unscheduled, records can be stored only during times when the drive signal is at full level. If level scheduling (profile or cycles) is used records can be stored at all times that the drive signal is not at low level.

When the test terminates, due to normal completion or an abort condition, the spectra currently in the system memory are written to the spectrum file as a final record in the spectrum file. The total number of records in the file is therefore one greater than the number of your specified records.

A setup parameter allows you to select either of two options that govern how frequently records can be stored during the valid storage periods. The options are auto-store and manual store. In auto-store mode record storage occurs automatically at regular intervals, where you specify the interval. With manual mode, a record is stored only when you press the right-arrow (→) key.

Record storage is limited to a maximum of once per loop, even if the interval (auto-store) or successive key pressing (manual store) requests more frequent storage. Both auto-store and manual store are permitted for test scheduling and remote control.

2.9.5 Spectrum Storage during Analysis Function

The spectra generated during execution of the analysis function may also be stored on disk in the same fashion as for the test function, with a filnam.typ of the form testid.Rmm and up to 99 runs for the same test ID. Again, storage is limited to runs with 100, 200, or 400 lines of resolution.

The records in an analysis function file are the same as those for a test function file except that only monitor, auxiliary, transmissibility, and inverse transmissibility spectra are present (i.e., control, reference, drive, and error spectra are not included).

Records are stored at all times when the analysis function is in execution. Either auto-store or manual store mode may be selected.

2.9.6 Spectrum Retrieval for Data Replay

The spectra stored on disk during an execution of the test function or the analysis function can be retrieved for later examination as a part of the data replay function. In addition to spectra stored during a test, the final spectra that exist at the end of the test remain in the system memory buffers and can be stored along with setup parameters as part of the setup function procedure (see paragraph 2.9.1). However, these spectra provide only a static picture of conditions at the conclusion of a test and cannot provide the same information as a full file of spectra stored throughout the test duration.

The dialog that takes place on the CRT when the data replay function is selected is given below. Your responses are in bold print.

```
TEST ID: XXXXXX
SYSTEM DEVICE UNIT NO: n
RUN NO: nn
TIME HRS, MIN, SEC: n,n,n
```

The first three lines specify the name and location of the spectrum file and associated setup file to be retrieved. The last line selects the record to be first retrieved from the spectrum file. The program locates both files and then selects a record of the spectrum file for display.

The initial record selected for display is the first record in the spectrum file with an elapsed time value equal to or greater than the time selected. An elapsed time value is stored as part of each record (see paragraph 2.9.1). This record is read into memory and one of the spectra in the record displays. The spectrum type displayed and all other display parameters are determined by the current main menu settings. You can change the spectrum type and other display characteristics by altering the menu selections.

Having retrieved a particular record from the spectrum file, you can then exercise control over the retrieval of subsequent records in the file via the up-arrow (↑) and down-arrow (↓) keys. The ↓ key serves as a toggle between single record and continuous record retrieval. The system is initially in single record mode. In single mode the retrieval process halts after each record is read into memory. To advance to the next record press the ↑ key. In continuous mode the records are read and displayed one after another. The ↑ key is not active, but you can halt the continuous retrieval process at any time by pressing the ↓ key, which returns the system to single mode.

This process continues until the last record in the file has been read, or until you wish to break the retrieval sequence. To break the sequence, you press the MARK

key. This stops the data replay activity, sets the retrieval mode to single record, and causes the following dialog to appear on the CRT:

```
1 = TEST ID
2 = RUN NO.
3 = START TIME
?
```

Responding with 1 causes the data replay dialog to reappear starting at line 1. This allows retrieval of another spectrum file with a different test ID.

Responding with 2 causes the dialog to recur starting with line 3. This allows retrieval of a spectrum file with the same test ID but a different run number.

Responding with 3 causes the dialog to recur starting at line 4. This allows a new retrieval sequence from the same spectrum file but a new time value.

Press the ABORT key to exit from the data replay function and return to standby with the menu active.

2.9.7 Test Log Storage of Post-Test Messages

If the test log function is enabled, the contents of the post-test message is written as a one-block record into the active test log file at the conclusion of each test. This storage occurs automatically for both normal test completions and aborted tests, without any post test action by you. Specifically, it is not necessary to call the post-test function to cause test log storage. Storage takes place at the end of each test as long as test logging is enabled and unused space remains in the active file. If file space is exhausted at the start of the next test the message LOG FILE FULL -PROCEED (Y/N)? displays, giving you the choice N, of stopping the test and opening a new test log file or Y, of proceeding with this and subsequent tests with test logging disabled.

2.9.8 Test Log Report Generation

Retrieval and display of the contents of a test log file is not performed by the RANDOM program, but rather by a separate stand-alone report generation program (REPORT.SAV) supplied with RANDOM. The report program is written in FORTRAN and is also supplied in source language form (as file REPORT.FOR) to allow you to modify the report as required to suit individual needs, using a text editor program and the FORTRAN compiler. The report format generated by the standard REPORT program is shown in Figure 2-12. Your input is in bold print.

2.9.9 Summary of Program Created Filespecs

The file specifications of the files created by the RANDOM program include file names that are the test ID parameter taken from the parameter set in effect when the file is formed, and file extensions that are assigned by the program so that files

of different types are not confused with each other. The following gives the file name and extensions used:

Setup file	testid.RN
Spectrum file	testid.Rxx (01 $\leq$ xx $\leq$ 99)
Test schedule file	testid.RNQ
Test log file	testid.RLx (0 $\leq$ x $\leq$ 9)

The following table gives the disk space (in blocks) required by each of the above file types:

Setup parameter file, no menus and spectra	5
Setup file with menu and 100-line spectra	9
Setup file with menu and 200-line spectra	12
Setup file with menu and 400-line spectra	18
Each record of spectrum file with 100-line spectra	3
Each record of spectrum file with 200-line spectra	6
Each record of spectrum file with 400-line spectra	12
Test schedule file for any number of entries	2
Test log file with space for n post-test messages	n+1

The default parameter file named RANDOM.RN is ready to automatically load parameters into system memory when the program starts. When you change these parameters but keep the same testid, be sure that you also remove the data storage files. (See note in paragraph 2.9.1.2.)

The following dialog shows the report generation program operation.

ENTER THE TEST LOG FILENAME:

• GR2511.RL4

Enter the filespec of the file to be read by the REPORT program. If the type is omitted a default type of .RL0 is used.

ENTER THE REPORT FILENAME:

• REPORT.LST

Enter the filespec of the file to be written by the REPORT program. A default type of .RPT is used if the type is omitted.

(The CRT is erased)

TEST LOG SUMMARY

Record	Date	Time	Elapsed Time	Status	Test Code
1	19-Nov-84	12:5:18	0,2,0	Completed	Lot 27
2	19-Nov-84	12:7:57	0,2,0	Completed	Lot 28
3	19-Nov-84	12:10:35	0,0,41	Aborted	Lot 29
.	.	.	.	.	.
.	.	.	.	.	.

ENTER THE RECORD NUMBER OF THE POST TEST MESSAGE
TO BE DISPLAYED

(0 = EXIT)

n

To exit from the REPORT program, enter 0 (zero) as the response n.

To cause display of the complete post-test message for one of the records listed in the above summary, enter the number 'n' of the record. (Out of range numbers are rejected and the message is redisplayed.) Following the post-test message, the ENTER THE RECORD. . . message is redisplayed to allow selection of another post-test message.

Figure 2-12. Test Log Summary Report Format

2.10 PROGRAM GENERATED MESSAGES AND QUERIES

This paragraph contains a list of the messages and queries generated by the RANDOM program to inform you that any of various events or conditions has occurred. The messages are displayed in the message block (item 1 in Figure 3-1) and the queries are flashed in the query block (item 2) of the summary information area of the CRT display.

The message and query blocks contain room for only one message and one query, respectively. This does not lead to a loss of information, as the messages and queries usually occur singly. When more than one message is generated, the messages are displayed in the order in which they occur with earlier messages

erased and replaced by later messages. If these messages are generated once each loop, the display of multiple messages recurs in a repetitive pattern for successive loops while the messages are active.

The program also generates an audible signal at the system keyboard, as a special type of alarm message to you. Paragraph 2.1.1 includes a list of the situations in which the audible alarm occurs.

2.10.1 Message Block Contents

2.10.1.1 'A/D CLOCK OUT' TO 'D/A EXT CLOCK' OPEN. Occurs if the clock connection between the A/D and D/A hardware (see paragraph 1.6.3) is not completed. If this condition exists no program function can be executed; the program forces a return to standby with the menu active. The connection must be made before program operations can be continued.

2.10.1.2 ALARM LINES: x, y, z, . . . Occurs during test or analysis function if one or more external signal lines designated as alarm lines indicate an alarm condition. The quantities x, y, z, . . . are the numbers of these lines. This message occurs only if the optional remote communication and external alarm/abort hardware is present in the system.

2.10.1.3 DISK FULL. Occurs during data storage while in setup, test, or analysis function when there is no room on the selected disk unit for further storage of data. When this condition occurs spectrum storage halts and the data file closes, but the test (or setup or analysis) continues.

2.10.1.4 DISK I/O ERROR. Indicates an error in a disk operation (disk read, write, or directory lookup). Can occur whenever disk operations are made, for example in the setup function, data storage in the test or analysis function, or in the data replay function. The most common reasons for this message are: insufficient contiguous unused blocks on disk, insufficient room in directory, illegal directory or disk format read/write error.

2.10.1.5 DRIVE OVERLOAD. Occurs during test function if more than a threshold number of lines (about 3%) in the drive spectrum saturate in value as the result of drive spectrum update in the equalization process. This condition causes software clipping of the drive signal, resulting in poor quality control of the external load. The condition usually results from a gain setting in your external equipment that is too low for the requested test parameters. This message is to alert you; the test is allowed to continue and is not aborted.

2.10.1.6 END-OF-DATA. Occurs in data replay function when the file from which data is being retrieved is exhausted. Program remains in replay function; press the (←) key to start a new retrieval sequence or the ABORT key to return to standby.

2.10.1.7 FILE NOT FOUND. Indicates that a directory search was made for a file on a device and the file is not present. This can take place in the setup, test, or data replay function when you are asked to supply a file name. Following this message the program repeats the query that requests the file name.

2.10.1.8 NO REMOTE HARDWARE!. Occurs during the setup function if remote control or external alarm/abort lines are requested, and the remote control option hardware is not present in the system.

2.10.1.9 ILLEGAL RUN #. Occurs in the data replay function if a run number outside the legal range of 1-99 is specified.

2.10.1.10 INPUT OVERLOAD. One or more sampled values on some control channel or the auxiliary channel have exceeded the full-scale input sensitivity. This means that saturation (clipping) has occurred on this channel and may cause poor quality control of the external load. This is an alarm message only; the test is allowed to continue and is not aborted.

2.10.1.11 LOOP CHECK STARTED. Occurs when either the stand alone loop check function, or the loop check portion of the test function, begins execution.

2.10.1.12 LOOP OK. Occurs at the normal completion of loop check when no loop errors have been detected.

2.10.1.13 NO FILE FOR SEQ NO x. Occurs during remote control operation if a test sequence number (x) supplied on the remote SEQUENCE lines is larger than the largest sequence number present in the test schedule file. If this condition occurs the test schedule aborts and the program returns to standby. Your action is required to restart the test.

2.10.1.14 NOISE ON SIGNAL — CH x. Occurs if a noisy loop condition is detected on control channel "x" during execution of the loop check. If this condition is detected during a pre-test loop check the following query is displayed in the query block on the system CRT to allow you to halt the test if desired.

PROCEED? (Y/N):

If you respond with Y (yes) the test continues. If a N (no) response is given the program returns to standby.

2.10.1.15 NO. OF ALARM LINES = x. Occurs during a test execution and indicates that x lines of the control spectrum $|C_E|_N^2$ are outside of the alarm limit tolerance bands. This is a warning message only; the test is allowed to continue. (Note that this message does not indicate which lines are out-of-tolerance. To obtain this information you should enable display of the tolerance bands, select display of the control spectrum, and inspect the display.)

2.10.1.16 OPEN CONTROL LOOP — CH x. An open loop condition has been detected on control channel x during execution of the loop check. The program returns to standby; no test is executed.

2.10.1.17 PRESTORED DRIVE ACTIVE. This is an alert message that occurs at the start of test function execution if the setup parameters for the test specify prestored drive. If the CONFIRM AFTER START setup question was answered yes, the following query displays in the query block on the system CRT to give you a choice of allowing the test to continue or of halting the test:

PROCEED? (Y/N):

A Y (yes) response allows the test to continue, a N (no) response causes the program to return to standby.

2.10.1.18 SHUTDOWN INITIATED. Occurs during test function when any ABORT condition is triggered. This message is replaced by the TEST ABORTED message when shutdown is complete.

2.10.1.19 SYSTEM GAIN. This message displays when the loop check function determines that all control channels are closed. A system gain is determined for each channel and displayed. The ratio of drive grms to control grms is the system gain.

2.10.1.20 TEST ABORTED — SEE POST TEST. Indicates that a running test was aborted, that test shutdown has been completed, and that the program is in standby state.

2.10.1.21 TEST COMPLETED — NEXT TEST SCHEDULED. Indicates that a test has completed normally when test scheduling is in effect, and that the next test in the schedule is being started.

2.10.1.22 TEST COMPLETED — SEE POST TEST. Indicates that an unscheduled test, or the last scheduled test, has completed normally and that the program has returned to standby state.

2.10.1.23 TEST LOG DISABLED. Occurs at the start of a test and indicates that test logging is turned off. This is the default state of the program and the message occurs even if the test log function is never executed.

2.10.1.24 TEST LOG ENABLED
ACTIVE LOG FILE IS testid.RLx ON UNIT n

This occurs at start of test. Indicates that test logging has been enabled via the test log function. The message also includes one of the following additional lines.

- a. LOG RECORD x OF y
TEST CODE:

LOG RECORD x is the number of the record to be filled for the test just starting, and y is the total number of records allocated to the active log file. Your entry of the test code for each test has been specified. Control remains at this point until a test code (maximum of 8 characters) is entered.

- b. LOG RECORD x OF y
TEST CODE FOR EVERY TEST = x...x

Same as for (a) except that a constant test code (x...x) for all tests was specified when test logging was enabled. Your input is not required; the test proceeds normally.

- c. LOG FILE FULL
PROCEED? (Y/N):

Indicates that all records in the active log file are filled. Control remains at this point awaiting your response. Respond with Y (yes) to continue with the test with test logging disabled for this and subsequent

tests. Respond with N (no) to abort the test and return to standby. This gives an opportunity to execute the test log function and define another test log file.

2.10.1.25 TEST SCHEDULE COMPLETE. Occurs immediately following completion of the last scheduled test when test scheduling is in effect. This message is replaced by the TEST COMPLETED message when shutdown is complete.

2.10.1.26 VERSION — x.x. Occurs when RANDOM program loaded and indicates the version number of the program.

2.10.2 Query Block Contents

2.10.2.1 PROCEED? (Y/N): Queries of this form occur in conjunction with the NOISE ON SIGNAL, SYSTEM GAIN, PRESTORED DRIVE, and TEST LOG ENABLED messages. See paragraph 2.10.1 for details.

2.10.2.2 LOOP CHECK MAX DRIVE (VOLTS): Occurs in the standalone loop check function only. Respond with a floating point number in the range .01 to 10.0 that specifies the maximum drive signal voltage to be output during loop check.

2.10.2.3 MAXIMUM EXPECTED GRMS: Occurs at the start of the analysis function. Respond with a number (in g) representing the largest expected overall spectrum level for any one control channel.

One of the four query sequences described below occurs when you press the MODIFY key during execution of the test function. The four types of test modification are:

REFERENCE	(modify reference spectrum)
AUX CHANNEL	(assign new auxiliary channel)
DRIVE UPDATE	(enable or disable drive update)
CURSOR LIMIT	(set lower and upper frequency limits)

One of the following query sequences is initiated, depending on which of the above selections is in effect for the test modification menu parameter when you press the MODIFY key.

2.10.2.4 REFERENCE: If selected, the following query occurs:

Change (dB or -dB):

Respond with a positive or negative integer value, specifying the amount that a selected portion of the reference spectrum is to be increased or decreased.

2.10.2.5 AUX CHANNEL: If selected, the following query occurs:

AUXILIARY CHANNEL:

Respond with an integer value indicating the number of the input channel that will be the new auxiliary channel. The message repeats if you enter an illegal value.

If the new aux channel is a control channel, the information requested by the queries is already in the program and the queries are not required. The following two

additional queries occur if, and only if, the new auxiliary channel being selected is not also a control channel.

ACCEL SENS (MV/G):

Respond with a floating point number giving the accelerometer sensitivity (in millivolts/g) for the new auxiliary channel.

MAXIMUM EXPECTED GRMS:

Respond with a floating point number giving the maximum rms value of the spectrum expected on the new auxiliary channel.

2.10.2.6 DRIVE UPDATE: If selected, the following query occurs:

Drive Update (1=ON, 0=OFF):

Respond with 1 to enable (ON) or with 0 to disable (OFF) update of the drive spectrum. While drive update is disabled, control loop equalization does not occur.

2.10.2.7 CURSOR LIMIT: If selected, the following queries occur:

Lower Freq (Hz):

Upper Freq (Hz):

Respond to each message with an integer frequency value such that $0 < \text{lower freq} < \text{upper freq} < \text{bandwidth}$. If you give an illegal value, the query repeats. The values specify left and right hand frequency values, respectively. These values are used to delimit a frequency range either for display expansion, or for modification of a portion of the reference spectrum. Cursors display on the CRT only if the DISPLAY menu item is set to CURSOR.

2.10.2.8 TEST CODE: This query occurs in conjunction with the TEST LOG ENABLED message. See paragraph 2.10.1 for details.

2.10.3 Audible Alarms

If you enter keystrokes more quickly than the program can accept them, an audible alarm sounds. You should inspect the echoed characters of the response being entered to see if any characters have been missed and must be repeated.

An alarm tone generates each time an alarm message displays in the CRT message block area. In the case of a recurring alarm situation, the tone repeats once each loop.

During a test, a tone sounds five seconds before the test time elapses, informing you that the test is close to completion.

An audible tone sounds whenever the RANDOM program enters the standby state. The program returns to standby when the program is first loaded, when the menu is released to standby, and when any other function either terminates normally or is aborted.

2.11 REMOTE COMMUNICATION AND ALARM/ABORT OPTION

The remote communication and alarm/abort option requires special hardware that is not part of the basic system configuration. The hardware consists of cables and a test panel shown in Figure 2-13. This hardware provides 16 output lines and 16 input lines to the system. The same option hardware is used for remote control operation and for supplying external alarm/abort signals.

The vibration control system supplies +5 volt TTL gated logic signals on the 16 input lines. The interpretation of these signals is: +5V=1=high/active/open circuit (10 kilohms or greater), and 0V=0=low/inactive/closed circuit (100 ohms or less).

The remote device controlling the vibration tests must hold the lines inactive (0V) except when a line is to be recognized. To cause the RANDOM program to recognize a control line, the remote device must open the line (to +5V) for a certain minimum time.

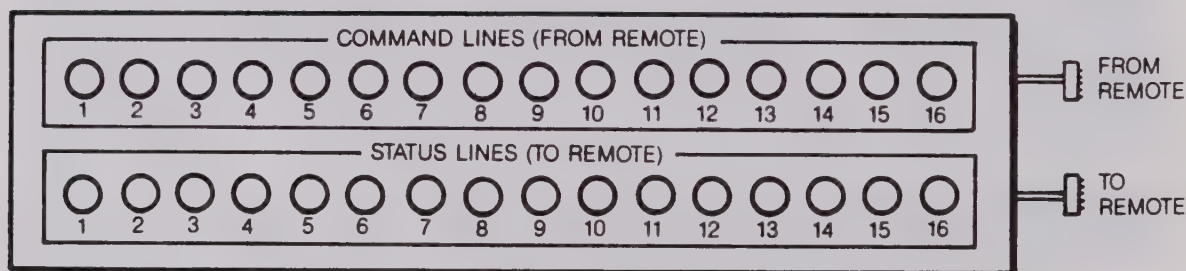


Figure 2-13. Test Panel, Remote Communication and External Alarm/Abort Option

2.11.1 Remote Communication

The remote communication feature allows test execution to be externally controlled from a remote device. The remote control capability involves use of the input lines of the option hardware to supply control signals to the system, and the output lines to provide program status information to the remote device.

2.11.1.1 Remote Input Lines. Remote control requires the use of test scheduling; remote control is in fact selected as an option (8=REMOTE, paragraph 3.3.8.9) of test scheduling during the setup function. If remote control is selected, you define some or all of the following input lines:

Name	No. of Lines	Function
REMOTE START	1	Load setup parameters
REMOTE READY	1	Remote device ready for test (optional)
REMOTE INCREASE	1	Leave test low level (optional)
REMOTE STOP	1	Stop test
SEQUENCE	1 to 6	Select next test number (optional)

The input (COMMAND) lines are numbered 1 through 16. Line definitions must be unique; the same number must not be assigned to more than one line. The signals supplied on the defined lines control the execution of each test and the order of the tests as described below.

REMOTE START When this line goes active and is recognized, the program initiates loading the setup parameter file for the next test to be run. This line is required to initiate each individual test in the schedule. REMOTE START is not interrogated until the REMOTE STOP line is inactive. REMOTE START must then be active for at least 10 milliseconds to be recognized.

If the optional REMOTE READY line is not used, test execution starts as soon as the setup file is loaded. However, if REMOTE READY is used the program waits after loading the file and does not output a drive signal until the READY line becomes active.

REMOTE READY This optional line may be used to provide a remote signal indicating that the remote equipment is ready for output of a drive signal. If this line is not used, test execution begins after the REMOTE START process is complete. If a READY line is defined, however, no drive signal outputs until the line goes active and is recognized. The READY line is not interrogated until the start process is complete, which may be up to 10 seconds if the setup file is loaded from floppy disk. READY must remain active for at least 10 milliseconds to be recognized.

REMOTE INCREASE This optional line allows a remote means of causing a test to leave low level. If auto start (see paragraph 2.7.2) is specified for a test, this line is not required and the test automatically leaves low level at the expiration of the specified time at low level. The INCREASE line may still be used in this case to cause the test to leave low level before the "auto low time" has expired. In addition, the up-arrow key (↑) for manual start is still active.

If manual start is specified for a test, then either the INCREASE line or manual use of the up-arrow key is required to cause the drive to depart from low level.

The INCREASE line is not interrogated until the system has completed one loop at low level. The line must remain active for at least one loop time to be recognized.

Since all test schedules are run in automatic mode, the test level automatically increases to full level (or to the first intermediate level for level profile) after a test leaves low level.

REMOTE STOP This line must be defined even if there is no intention to use it. It must be held inactive (low) to allow any test to be executed. The STOP line must be held active for at least 2 seconds to be recognized. When recognized, the line stops a running test and cause the test to shut down with its normal shutdown time. The program then awaits the next REMOTE START signal.

The STOP signal is not an abort condition. The test schedule may be continued following STOP. However, the STOP line must go inactive before a subsequent START is recognized.

SEQUENCE Use of SEQUENCE lines is optional. If no SEQUENCE lines are defined, tests are run sequentially in their order of appearance in the test schedule (except as modified by the LOOP, CYCLE, or RESUME options). If SEQUENCE lines are defined, they may be used by the remote device to select from the test schedule the sequence number of each test to be run.

When the REMOTE START signal is recognized, the program interrogates the SEQUENCE lines. The lines must be held at their desired state for at least 10 milliseconds when START is asserted to allow them to be recognized. If all the SEQUENCE lines are 0 (i.e. inactive/low) the program reverts to normal test scheduling, and runs the test in the schedule that follows the test previously run (as modified by LOOP, CYCLE, or RESUME if selected). This continues for subsequent tests as long as the SEQUENCE lines remain all 0.

Any time the lines are interrogated and found to be non-0, however, the non-zero value is taken as the sequence number (in the test schedule) of the test to be run next. The remote device can thus specify the numbers of all tests to be executed, or can allow the order of test execution to be sequential from the schedule, or can select a combination of these choices.

Up to six line numbers can be defined as SEQUENCE lines, where the line numbers must be consecutive. When the lines are interrogated, each is found to be either 0 (low) or 1 (high). The value associated with the lines is the sequence number of the test to be run next, and is computed as the sum of individual line values (0 or 1) with a binary weighting. If six SEQUENCE lines are defined and the lowest line number is "n", the binary weighting is as follows:

Line number:	n	n+1	n+2	n+3	n+4	n+5
Binary weighting:	1	2	4	8	16	32
Computed seq. number:	$\sum_n^{n+5} \{(\text{line value}) \times (\text{binary weighting})\}$					

Two examples are given below. In the first, the six lines 3 through 8 are defined as SEQUENCE lines with values 100110. In the second, the four lines 5 through 8 are defined with values 0111.

Example 1:

Line number:	3	4	5	6	7	8
Binary weighting:	1	2	4	8	16	32
Line values (0 or 1):	1	0	0	1	1	0
Computed seq. number:	1 + 0 + 0 + 8 + 16 + 0 = 25					

Example 2:

Line number:	5	6	7	8
Binary weighting:	1	2	4	8
Line values (0 or 1):	0	1	1	1
Computed seq. number:	0 + 2 + 4 + 8 = 14			

Only as many SEQUENCE lines need be selected as are required to contain the highest sequence number that will be used. The following table shows the correspondence between the number of lines selected and the highest sequence number allowed.

<u>No. of Lines Selected</u>	<u>Highest Allowable Seq. Number</u>
1	1
2	3
3	7
4	15
5	31
6	63

2.11.1.2 Remote Output Lines. When the remote communication hardware is present the RANDOM program maintains status information on the output lines describing its current operating state. The output lines have the following significance for program status purposes.

<u>Status Type</u>	<u>STATUS Line Nos.</u>
Function status	1-2
Level status	3-4
Alarm/abort conditions	5-8
(not used)	9-16

FUNCTION STATUS (lines 2-1)

- 0 (00) TEST. Program is in loop check or test or analysis function with the function active and started. The alarm/abort status conditions indicate alarms.
- 1 (01) STANDBY. Program is in standby state. The alarm/abort conditions indicate aborts.
- 2 (10) TEST/HOLD. Program is in test function awaiting a response to a query. The alarm/abort conditions indicate alarms.
- 3 (11) NON-TEST. Program is in setup, post-test, or data replay function. The alarm/abort conditions are not significant.

LEVEL STATUS (lines 4-3)

- 0 (00) OFF. No drive signal being output.
- 1 (01) LOW. Program in test function in loop check, initial low level drive, or increasing toward full level.
- 2 (10) FULL. Program in test function with drive at full level, or at an intermediate level L_i with level profile in effect.
- 3 (11) (Not used)

ALARM STATUS (lines 8 through 5, for function status = 0 or 2)

- 0 (0000) No alarms.
- 1 (0001) g^2 /Hz alarm limit(s) exceeded (Priority 2).
- 2 (0010) grms alarm level exceeded (Priority 3).
- 3 (0011) External alarm line active (Priority 4).
- 4 (0100) MAX DRIVE message active (Priority 5).
- 5 (0101) Input channel overload (Priority 1).
- 6-16 (Not used)

If two or more alarm conditions occur simultaneously, the status lines indicate the condition of highest priority.

ABORT STATUS (lines 8 through 5, for function status = 1)

- 0 (0000) No abort.
- 1 (0001) Open control loop in loop check.
- 2 (0010) g^2 /Hz abort limit(s) exceeded.
- 3 (0011) grms abort level exceeded.
- 4 (0100) Control signal loss on channel(s).
- 5 (0101) Control signal loss due to low overall grms.
- 6 (0110) Operator abort.
- 7 (0111) External abort line active.
- 8-16 (Not used)

2.11.1.3 Remote Test Execution. The execution procedure for remote control operation of scheduled tests is similar to the procedure for test scheduling with local control and consists of the following steps:

- Step 1. Enter the setup function, load a test schedule file, and modify the retrieved copy of the schedule if required.
- Step 2. Return to standby from the setup function, and enter the test function. The test schedule is listed. Select either the START or RESUME option.

At this point the procedure for remote execution differs from local execution. For local execution the test specified by START or RESUME starts immediately. For remote execution the program starts interrogating the remote input lines. This leads to the start of either the test indicated by your START or RESUME command or a test specified by the remote device, depending on the SEQUENCE lines. Figure 2-14 shows the steps in this process.

While a test is executing the program monitors the REMOTE STOP line. The test ends normally if the test time expires or if REMOTE STOP goes active and is recognized. In either case the program proceeds to the next test. If an ABORT condition occurs, the test schedule terminates and the program goes to STANDBY. In this case you must act to restart the schedule.

2.11.2 External Alarm/Abort Lines

This portion of the option is the safety feature described in paragraph 2.6.6. The alarm/abort feature uses the input lines not defined for remote communications purposes. Since at most ten input lines may be used for remote control, a minimum of six lines are available as external alarm/abort lines.

Separate dialogs in the setup function allow you to assign lines for remote control and for alarm/abort use. In case the same line number is used for both purposes, the remote communications use takes precedence and the alarm/abort assignment is ignored.

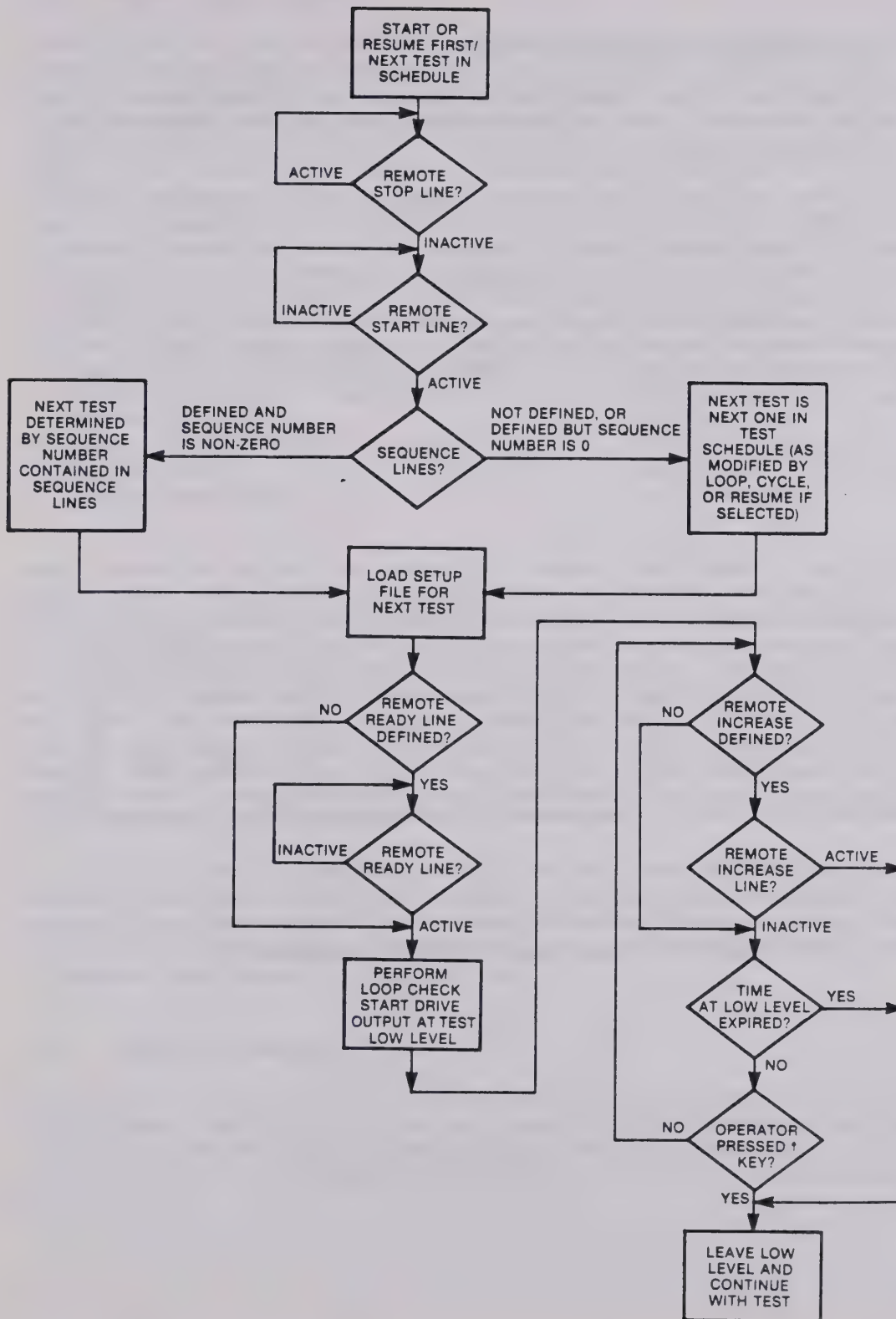


Figure 2-14. Interrogation of Remote Input Lines

2.12 THE 16-CHANNEL SELECTOR OPTION

The 16-channel selector option requires special hardware not supplied as part of the basic system. The option hardware consists of an input panel and cable assembly. The panel is shown in Figure 2-15.

The basic system configuration includes one A/D input channel, expandable with the purchase of additional hardware to four channels. Only one accelerometer input can be connected to each channel, giving a maximum of four control points. However, use of the 16-channel selector option allows up to 16 accelerometers on the external load to be connected to the one channel of the basic system, so that equalization can be performed using the averaged response data from up to 16 control points. The selector is a programmable device and is controlled automatically by the program, using your setup parameters that identify which of the 16 selector inputs are in use.

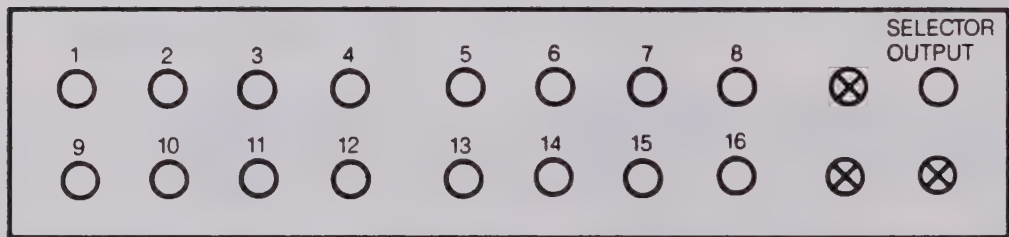


Figure 2-15. Input Panel, 16-Channel Selector

2.13 SAFETY FEATURES

Protection of the external load is of paramount importance. The RANDOM vibration program contains a number of safeguards for this purpose, designed to ensure that no abrupt change or out-of-tolerance condition in the drive signal level or shape occurs that might damage the test specimen or actuator equipment. If, during a test any of the safety features is executed, the test aborts and test shutdown occurs (see paragraph 2.13.5). A list of safety features and the frequency with which each feature is monitored is given below.

Feature	Monitored
Loop check function	Once per test
Control signal loss	Once per frame and loop
Control spectrum alarm and abort limits	Once per loop
Control spectrum grms alarm and abort level	Once per loop
Test shutdown time	Once per test
External alarm and abort lines (option)	N+4 times per loop
Operator abort	Continuous
Drive signal clipping	Once per frame

Each feature is designed to protect the external load under a particular set of circumstances. All features except your abort are automatic and hence do not add to your workload. Most of the safety features are monitored at least once per control loop; a minimum loop time is thus advantageous not only because it increases equalization speed but that it also allows more frequent safety checks. Time spent in the display task, which increases the loop time and during which certain safety features are not monitored, may be minimized either by turning the display off entirely, by omitting as many optional display features as possible (e.g., alarm limit tolerance bands), and by not changing the spectrum type displayed more often than necessary (each time the spectrum type is changed the display grid and labels must be computed and displayed, which lengthens the display task).

The safety features are intended to minimize to the greatest extent possible any chance of damage to the device under test. However, you retain final responsibility for proper preparation and maintenance of the external load and signal connections, appropriate use of the safety features, the selection of associated parameters, and careful selection of all maximum signal levels specified for a test.

2.13.1 Loop Check Function

The loop check is a continuity test of the control loop, including all connections to the external load. The objective of the loop check is to verify that all equipment in the control loop is connected and functioning, using very low drive voltage levels. You can specify the maximum drive signal level (the loop check maximum drive) to be used during the loop check.

The loop check function should in all cases be applied to an external load before the load undergoes a full test. If the equipment loop is actually open, then equalization cannot be achieved. On the other extreme, if the power or accelerometer amplifier gain settings are too low the loop may appear open when it is really closed. The loop check presents you with a means of testing the accelerometer gain settings and the selected loop check maximum drive, to determine that they are appropriate and safe for the external load.

In addition to being an independently executable function, the loop check executes automatically at the beginning of the test function, unless you deliberately suppress it. As a pre-test feature the loop check serves as a final test for loop continuity and also to establish the initial drive signal level to be used in the test.

The loop check outputs a very low level drive signal and gradually increases the signal level to the loop check maximum drive value. The loop check ends successfully when the program detects a control signal above a threshold level of 15 millivolts on each designated control channel. When this occurs the message LOOP OK displays and the drive signal level gradually decreases to zero.

Two types of loop check failure are possible, indicating different kinds of equipment problems in the loop: An open loop condition is reported if the drive signal level reaches the specified loop check maximum drive level and no control signal above the 15 millivolt threshold is detected on one or more of the control channels. A noisy loop is reported if a control channel signal above 15 mv is detected on any channel while the drive signal is at a very low level of output.

If the LOOP OK condition is recognized, the program calculates an estimate of the system gain based on the ratio of the averaged drive spectrum to the control spectrum. This gain is used in scaling the initial drive signal level for the test to 20% of the selected "test low level" value (see paragraph 2.6).

2.13.2 Control Signal Loss

The loss of a signal from any of the control channels during a test can have serious consequences for the test specimen. Such a loss means that information required to update the drive spectrum to maintain or achieve equalization is missing, and continued output of a drive signal will have an incalculable effect on the external load. For this reason detection of a control signal loss condition is extremely important, and is reason for immediate shutdown of the test.

Three different checks for loss of control signals are performed during each control loop of a test. One check tests the absolute level of each control channel spectrum; the other two look for relative changes in control spectrum levels between the current and previous spectra.

2.13.2.1 Check on absolute control spectrum level. This check is applied to each signal frame acquired from each control channel during all loops of a test. The check uses the overall rms gain for the external load that was calculated by the program during the automatic loop check that precedes the test. (If you suppressed the pre-test loop check, a gain of unity is assumed.) If the grms level of the control spectrum resulting from any frame of control signal data falls below an expected absolute threshold value (computed from the control loop gain), control signal loss is assumed and the program aborts the test and initiates shutdown.

This particular check on absolute control signal level is particularly important for the initial frame of a test since there is no "previous frame" data available and therefore the other two checks for relative change in control spectrum level cannot yet be performed.

2.13.2.2 Check on relative per-channel control spectrum level. This check begins with the second frame of input. It is applied from that point to each frame of data input from each control channel. The check consists of comparing the rms level of the spectrum computed from each frame with the rms level of the previous spectrum for the same control channel. A signal loss condition is assumed if the level of the new spectrum drops below $1/8$ the level of the previous spectrum, and shutdown is initiated.

2.13.2.3 Check on relative overall control spectrum level. This check is applied once per control loop, and compares the rms level of the exponentially averaged control spectrum for the current loop $|C_E|_N^2$ with that of the previous loop $|C_E|_{N-1}^2$. If the level of the current spectrum is more than 3 dB below the level of the previous spectrum and if the current spectrum level is also more than 3 dB below the rms level of the reference spectrum level, control signal loss is assumed and shutdown occurs.

Note: The abort message generated by the post-test function normally includes a control channel number if the abort was caused by control channel loss. For this condition no control channel number is present because the check pertains to the overall control spectrum.

2.13.3 Control Spectrum Alarm and Abort Limits

When the program has equalized the external load during a test there is a close match between the control spectrum and the reference spectrum. Conversely, failure to equalize results in significant discrepancies between the control and reference spectra. Failure to achieve equalization or loss of equalization during a test is often due to an equipment malfunction in the external load or to an extreme non-linearity in the structural response of the test specimen. Such a condition poses a potential hazard to the external load. You can specify alarm limits and abort limits for each frequency line in the reference spectrum, which are used by the program to automatically detect deviations of the control spectrum from the reference spectrum. For each line a pair of alarm limits can be selected in terms of dB above and dB below the reference spectrum level for the line. Separately and independently, a pair of abort limits can be similarly specified as dB above and below the reference spectrum. The only restraint placed on the alarm and abort limit values for a frequency line is expressed by the following relation:

$$\text{ABORT}_{\text{below}} < \text{ALARM}_{\text{below}} < \text{ref-spectrum} < \text{ALARM}_{\text{above}} < \text{ABORT}_{\text{above}}$$

The lower and upper alarm limits define an alarm limit tolerance band surrounding the reference spectrum. Similarly, the lower and upper abort limits define an abort limit tolerance band that surrounds both alarm tolerance band and the reference spectrum. The alarm tolerance band may be selected for display on the system CRT. The frequency range covered by the spectrum is 0 (Hz) to B (Hz), where B is the control bandwidth for the test. You can allow the alarm and abort limits to apply to this entire range or can restrict the frequency coverage to a portion of the spectrum. The number of out-of-tolerance lines required to trigger the alarm condition are selected. The number of lines required to cause the abort condition are separately selected.

When the test starts and before equalization is achieved the control spectrum typically deviates substantially from the reference spectrum. To prevent spurious alarms and aborts during this period, the alarm and abort limits are not activated for the first six loops of a test. Counting of these six loops begins during the time that the drive signal is at low level. In addition, the abort limits are not active after the reference spectrum has been modified during a test.

During each loop when the alarm and abort limits are active, the updated control spectrum $|C_E|_N^2$ is compared line by line to the limits. If more than the specified number of lines in the control spectrum fall outside the alarm tolerance band, an audible alarm sounds and a message displays on the CRT to alert you. If more than the specified lines are outside the abort tolerance band, the test is aborted.

2.13.4 Control Spectrum Grms Alarm and Abort Level

During test setup, the program calculates and prints on the CRT an overall spectrum energy value for your specified reference spectrum. The value is given in grms. Based on this overall grms value, you can select as setup parameters an overall grms value as an alarm trigger, and a separate overall grms value as an abort trigger, where

$$GRMS_{ref.} < GRMS_{alarm} < GRMS_{abort}$$

These alarm and abort levels are additional safeguards to prevent the level of the excitation of the external load from becoming too high. They operate in addition to the alarm and abort limits of paragraph 2.13.3, for the individual lines of the control spectrum may all be within the selected alarm or abort limits, and yet the total energy of the control spectrum may be too great and pose a danger to the test specimen. The grms levels for the overall spectrum guard against this condition. The alarm and abort levels are active at all times during a test and in both manual and automatic test mode.

Once each loop when the control spectrum $|C_E|_N^2$ is updated, an overall grms value for this spectrum is computed and compared with the alarm and abort levels. If a level is exceeded an alarm sounds or the test aborts, respectively.

2.13.5 Test Shutdown Time

Test shutdown occurs either normally when a test has accumulated the specified amount of execution time or as the result of an abort condition, either automatic or initiated by you. During test shutdown no further update of the drive signal occurs; the current drive signal continues to be output. The level of the drive signal is reduced from its value when shutdown is initiated to a level of -30 dB below full test level. At -30 dB the D/A converter is turned off and the drive signal is no longer output. The test shutdown time is your selected test setup parameter that specifies the time period over which the decrease in signal level to -30 dB shall take place. This parameter allows you to make a choice between speed and smoothness of shutdown that offers the best protection of the external load.

2.13.6 External Alarm and Abort Lines

The external alarm and abort lines are part of the remote communications option and require extra hardware not included in the basic system. This option provides the means of inputting 16 externally supplied signals to the program. The signals supplied must be TTL gated logic, with +5V = 1 = closed circuit (100 ohms or less) and 0V = 0 = open circuit (10 kilohms or greater). A minimum of 6 of the 16 signal lines are available for use as external alarm or abort indications (see paragraph 2.12.2). You designate the active alarm/abort lines as test setup parameters. Each active line may be specified as either an alarm indication or an abort indication (but not both). The trigger condition for the lines may be selected either as open circuit or closed circuit. If the specified condition occurs on an alarm line, a message including the line number is displayed on the CRT and an audible alarm sounds. If the trigger condition occurs on one or more abort lines the test is automatically shut down; the abort message generated by the post-test function contains the number(s) of the line(s) on which the abort condition was detected. During a test the external alarm/abort lines are monitored $N+4$ times per control loop, where N is the equalization parameter (see paragraph 2.5.2).

2.13.7 Operator Abort

A key on the system keyboard is specially designated the ABORT key. The program continually monitors this key. You may at any time cause an immediate program shutdown by pressing the ABORT key, to safeguard the external load if a dangerous or abnormal situation occurs during a test.

2.13.8 Drive Signal Clipping

The drive signal clipping feature does not result in an alarm or a test abort, but you can use it to safeguard the external load by specifying a maximum signal level that the drive signal is not allowed to exceed. This is done by clipping (truncating) the drive signal to this maximum level if the level is exceeded. If selected, drive clipping is applied to each drive signal frame.

Two means are provided for specifying the drive signal maximum level (clipping level). These are called voltage clipping or sigma clipping.

In voltage clipping, the maximum drive level is given directly as an absolute value in volts, and the drive signal is truncated to this level whenever it would otherwise exceed the specified maximum.

In sigma clipping, the clipping level is set as a multiple of the rms voltage of the drive signal. For instance, if 2.5 is entered as the sigma clipping parameter, the clipping level is 2.5 times the rms voltage of the drive signal frame. With sigma clipping the clipping level is not absolute but changes as the level of the drive signal changes.

The drive clipping is accomplished by the software, which acts on each output time history buffer in memory. All values in the buffer that are above the maximum value (as established by sigma or voltage) are truncated and replaced with the maximum value. As each digital buffer passes through the D/A converter, an analog signal is created with flat plateaus where the clipping occurred. This analog signal now passes through the output smoothing filter, where the flat plateaus cause the filter to overshoot or ring at

the filter cutoff frequency. The analog drive signal now contains more high frequencies, and the peaks are slightly higher than the clipped value. This overshoot or ringing partially negates some of the software clipping that occurred earlier. For sigma clipping, a 10% overshoot is common. As clipping becomes more severe (e.g., 2 sigma) the drive level increases due to the control algorithm compensating for the clipped peaks.

Drive clipping degrades the system dynamic range. When drive clipping is enabled, harmonics of all frequencies present in the drive spectrum are now generated and added to the output signal. Harmonic generation decreases system dynamic range by "filling in" any notches present in the drive spectrum. Thus, loads requiring maximum dynamic range may show control spectra approaching the positive alarm or abort tolerances.

SECTION III

OPERATING PROCEDURES

3.1 INTRODUCTION

This section provides necessary information for executing the functions of the RANDOM program. Separate paragraphs are devoted to the detailed operation of the individual program functions, and also to certain significant features and capabilities of the program.

When the program is first loaded, an initial set of load-time values for the menu parameters and setup parameters are present in the system memory. In particular, the menu function parameter is set to STANDBY and the display parameter is set to STANDARD, and the program is therefore in a standby state and the CRT contains the spectrum display.

To select and execute a program function the program must be in STANDBY. To proceed from that point, press the MENU key, change the function parameter selection from STANDBY to the desired function, and then press the EXECUTE key. Execution of the selected function then begins. To terminate a function, press the ABORT key. The ABORT key is active at all times and when pressed immediately returns the program to its standby state. When the aborted function is a vibration test (the test function), the program terminates the test by initiating test shutdown. Although the ABORT key is used most frequently to stop a test, ABORT may also be used to terminate any other program function.

If the setup parameter file RANDOM.RN is on the system disk when the program is first loaded, these parameters are read into system memory and replace the initial set of parameters.

3.2 OPERATOR PROGRAM CONTROL

3.2.1 Control Parameters and Control Devices

Program operation is governed by two groups of parameters: setup and menu. These values are fixed and invariant during execution of the test or any other program function. The setup parameters are described in paragraph 3.3. Menu parameters are available for change throughout a test, except during your dialog or response to a program query. The control menu and menu parameters are discussed in detail in paragraph 3.2.3.

The RANDOM program is completely controlled via the system CRT and keyboard. All input to the program is made by keyboard entry, and all program output consists of CRT displays and audible alarms generated at the keyboard.

Keyboard input can be of the following three types: (1) general use of all keys for alphanumeric input of setup and menu parameters, and responses to program dialogs or queries; (2) use of certain keys for special program control functions; and (3) annotation of standby and data replay displays (see paragraph 3.2.2). The locations of the special function keys on the keyboard are shown in Figure 3-1. The functions performed by these keys are described below in paragraph 3.2.2.

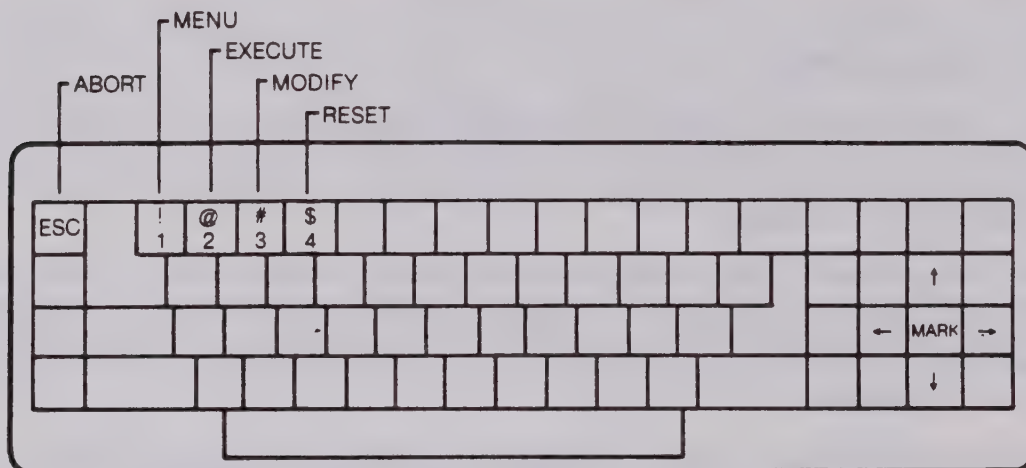


Figure 3-1. Keyboard Special Function Keys Locations

3.2.2 Special Function Keys

Only the four keys of the ten special function keys, numerals 1 through 4, are required for non-special, alphanumeric input purposes. Because of this potential conflict of use, the MENU, EXECUTE, MODIFY, and RESET special functions are not active during dialogs or responses to a program query. The other special keys, especially ABORT, are not subject to this restriction.

3.2.2.1 ABORT. Key is active at all times*. If the ABORT key is pressed when the program is in test or analysis function, shutdown is immediately initiated. When shutdown is completed the program returns to standby. If the program is in loopcheck, setup, post-test, or data replay function when ABORT is pressed, the program goes immediately to standby. In addition, the ABORT process also cancels any test modification process that is active when the ABORT key is pressed.

* The only condition under which the ABORT key is not active is when a copy of the CRT contents is being produced on the optional printer/plotter. In this case it is necessary to stop the copy process by pressing the ALARM/CLEAR key on the printer/plotter, in order to restore the ABORT key to active status. See also paragraph 3.5.3.1.

3.2.2.2 MENU. Key is active at all times except during a dialog or response to a program query, or when the menu is already active. Pressing the MENU key activates the control menu (see paragraph 3.2.3). The menu displays on the CRT, replacing the spectrum display if it was present. Menu selections can then be made.

3.2.2.3 EXECUTE. Key is active only when the control menu is active and if no dialog or response is on-going. Pressing EXECUTE releases the menu, starts execution of the currently selected program function, and applies the current values of all menu parameters to the program.

3.2.2.4 MODIFY. Key is active only if the menu MODE parameter is set to MANUAL, the menu is not active, and no dialog or response is on-going. Pressing MODIFY initiates the query sequence for the currently-selected modification selection. (See the selections for the test modification menu parameter in paragraph 3.2.3 and also paragraph 2.10.2). At the completion of the query sequence, the requested modification takes effect.

3.2.2.5 RESET. Key is active only during execution of the test or analysis function, and if no dialog or response is on-going. The RESET key has no effect on test conditions or on any setup or menu parameters. RESET applies only to the monitor and auxiliary spectra. Pressing RESET causes the existing monitor and auxiliary spectra to be discarded, and causes calculation of new spectra to begin using the current monitor/auxiliary averaging type and parameter values. The effect of the RESET key is visible only if the monitor or auxiliary spectrum is displayed when the key is pressed.

3.2.2.6 MARK. Key has the following functions:

- When entering or editing the header or comments setup parameters, MARK terminates the parameter edit or entry process and accept the entire character string. (See paragraph 3.3.4.1.)
- When executing the data replay function, the MARK key halts a data retrieval sequence and causes display of the data replay dialog. (See paragraph 2.13.6 and 3.10(6).)
- Except for (1) and (2) above, the MARK key is active only when the control menu is displayed and active. Pressing MARK displays the list of available selections for the censored menu parameter. The list is erased if the pointer is moved to another parameter; you must press MARK again to cause the selections list for the other parameter to appear.

3.2.2.7 CTRL/L. (CTRL and L keys are pressed simultaneously.) This key combination has effect only when the program is in standby or in the data replay function, and the CRT contains a spectrum display. In these situations, CTRL/L

acts as a toggle switch to allow use of the alphanumeric keys for adding annotations to any locations on the display. Successively pressing CTRL/L switches the toggle on, off, on, off, etc.

When the toggle is ON, normal use of the keyboard for program control is disabled. A cursor (the underline character) appears in the upper left corner of the display graticule. Use the up, down, left, and right arrow keys to position the cursor to any location on the display, then use the alphanumeric and punctuation symbol keys to add an annotation at the cursored point. Any number of annotations may be made in this manner.

When all desired annotations have been made, pressing CTRL/L again switches the toggle OFF. The cursor character disappears and normal keyboard control of the program is reinstated. The ABORT key remains active when the toggle is ON, and if pressed will terminate annotation mode and restore keyboard control. ABORT thus is an alternate to CTRL/L to switch the toggle off.

The annotations are temporary and exist only in the display refresh memory. If the control menu is called up and the spectrum display then re-generated (by pressing the MENU and then the EXECUTE key) the annotations added via CTRL/L are lost.

3.2.2.8 STATE, C. (Press STATE key, then press C key.) During execution of the setup function, this two-key stroke sequence toggles between upper and lower case alpha characters, when responding to a yes/no query or when entering or editing the header or comments parameter.

3.2.2.9 Up Arrow (↑) and Down Arrow (↓). These keys have several functions depending on the program conditions in effect:

- When the control menu is displayed and active, the ↑ and ↓ keys move the menu pointer up and down, respectively, to allow selection of any of the menu parameters. The motion is in a circular fashion. If the cursor is moved off the top (bottom) of the column of parameters it reappears at the bottom (top). Holding either key pressed causes continuous pointer motion in the indicated direction.
- When executing the test function with manual start, press the ↑ key to cause the test to leave low level. (See paragraph 2.7.2(1).)
- When executing the test function in manual mode, press the ↑ or ↓ key to cause the test to increase or decrease, respectively, from each intermediate level between low level and full level. (See paragraph 2.6.2.2 and 2.6.2.3.)
- When executing the data replay function, the keys have the following use: If single record retrieval is selected the ↑ key causes retrieval and display of the next record. The ↓ key serves as a toggle switch between single record and continuous record retrieval. (See paragraph 2.13.6.)
- When the CTRL/L toggle is on, the ↑ and ↓ keys respectively move the annotation cursor up and down.

3.2.2.10 Left Arrow (←) and Right Arrow (→). These keys have the functions described below:

- When the control menu is displayed and active, these keys change the selection of the menu parameter indicated by the pointer, among the values in the list of available selections for that parameter. The ← key moves the selection upwards in the list; the → key moves the selection downward. The changing is circular, and either key if held pressed causes continuous change of selection in the indicated direction.
- When executing the data replay function, the ← and → keys move the cursor left and right on the display. (See paragraph 3.10.9.)
- If spectrum storage is being performed in the test or analysis function and if manual store mode is selected, press the → key each time storage of a spectrum record is desired. (See paragraphs 2.13.4 and 2.13.5.)
- When entering or editing the header or comments setup parameters, the ← and → keys position the point-of-type cursor to any character within the parameter character string.
- When the CTRL/L toggle is on, the ← and → keys respectively move the annotation cursor to the left and right.

3.2.3 Control Menu

When the RANDOM program is loaded and starts operation, it is initially in standby and the CRT displays the control menu.

In order to leave the standby state, alter the display, execute a test function, etc., you must alter the values of the menu parameters. This is done by pressing the MENU key to activate and display the menu (if it is not already displayed); the menu parameters may then be modified. The menu is available at all times except during dialog or response to a program query. (This means that the menu is not available during execution of the setup function, since setup consists entirely of dialog.)

The control menu parameters allow you to select which of the eight program functions to execute; to select manual or automatic mode for the test function; to select the spectrum type to be shown on the spectrum display and to specify other spectrum display parameters; to select and re-select averaging parameters for the monitor and auxiliary spectra; and to initiate any of the four kinds of test modification (modify reference spectrum, change auxiliary channel, disable/re-enable drive update, or expand display).

The menu display includes a pointer symbol (=>), a list of the menu parameters arranged vertically, and a corresponding list showing the value currently in effect for each menu parameter. This structure is shown in Figure 3-2; the parameter values shown in the figure are the initial values in effect when the program is loaded.

-20 dB

```

=> Function Mode STANDBY
Spectrum CONTROL
Display
  Vertical Scale STANDARD
  Max Value 6 DECADES
  Horizontal Scale 0.1
  Graph LINEAR
  Auto Erase LINE
  Tolerance Bands ON
  Cross-Hatch OFF
Monitor/Auxiliary Avg. EXPONENTIAL
Type 8
Parameter
Test Modification CURSOR LIMIT
  
```

Figure 3-2. Control Menu Format with Load-Time Parameter Values

Use of the menu involves the MENU, EXECUTE, arrow ($\uparrow$, $\downarrow$, $\leftarrow$, $\rightarrow$) and MARK special function keys as described in paragraph 2.11.2. Activate the menu by pressing MENU, press the $\uparrow$ and $\downarrow$ keys to position the menu pointer to a parameter to be changed, and press the $\leftarrow$ and $\rightarrow$ keys to select a value for the parameter. When all desired parameter values are selected press EXECUTE to release the menu, apply all the (new) parameter values to the program, and execute the selected program function.

The MARK key, when pressed, causes a list of the selections (values) available for the parameter currently indicated by the pointer to be displayed to the right of the menu. The remainder of this paragraph consists of the lists of the available selections for each menu parameter, with comments or descriptions added where the parameter or list items are not self-explanatory.

Menu Parameter	Comments
Function	Select program function.
SETUP	
STANDBY	
TEST	While in TEST function no other function is selectable.
POST-TEST	
ANALYSIS	While in ANALYSIS function no other function is selectable
DATA REPLAY	While in DATA REPLAY no other function is selectable.
LOOP-CHECK	
TEST LOG	
EXIT	Exit from the program and return to RT-11 system.

<u>Menu Parameter</u>	<u>Comments</u>
Mode	Select mode for test function. MANUAL mode is not selectable if the AUTOMATIC ONLY setup parameter question is answered Y(es).
MANUAL	
AUTOMATIC	
Spectrum	Select spectrum type for spectrum display.
REFERENCE	
MONITOR	
CONTROL	
DRIVE	
AUXILIARY	
TRANSMIS	
1/TRANSMIS	
ERROR	
Display	
STANDARD	The ON state for the spectrum display.
EXPAND	Displays only the specified frequency range.
CURSORS	Adds the frequency range cursors to the STANDARD display.
OFF	Turns the display OFF to decrease the loop time.
PLOTTER TEK	Directs current display to digital plotter. (This selection does not appear if the plotter interface hardware is not present in the system.)
PLOTTER HPGL	
Vertical Scale	Select linear or log vertical scaling for spectrum display.
LINEAR	
2 DECADES	
4 DECADES	
6 DECADES	
8 DECADES	
10 DECADES	
Max Value	Select maximum value for vertical axis on spectrum display.
<u>Max Value</u> <u>(Vertical Scale = log DECADES)</u>	<u>Max Value</u> <u>(Vertical Scale = LINEAR)</u>
10**-4	0.01
10**-3	0.05
0.01	0.1
0.1	0.5
1	1
10	5
100	10
1000	50
10**4	100
10**5	500
10**6	1000

Menu Parameter	Comments
Horizontal Scale	Select scaling for horizontal axis on spectrum display.
LOG	
LINEAR	
Graph	
POINT	Spectrum trace on display is unconnected points.
LINE	Spectrum trace is connected points.
Auto Erase	
OFF	Spectrum trace not erased after each loop.
ON	Spectrum trace erased after each loop. (Auto Erase in forced OFF if Cross-Hatch is ON.)
Tolerance Bands	
OFF	Do not display tolerance bands.
ALARM	Add alarm tolerance bands to spectrum display.
ABORT	Add abort tolerance bands to spectrum display.
Cross-Hatch	
OFF	Tic marks on display axes not extended.
ON	Tic marks extended as dotted lines across display. (Forces AUTO ERASE to OFF condition.)
Type	Selects averaging type for monitor and auxiliary spectra.
EXPONENTIAL	Discount averaging, $ S_E _N^2 = (1-1/P) S_E _{N-1}^2 + (1/P) S _N^2$
LINEAR	Summation averaging, $ S_L ^2 = (1/P) \sum_{i=1}^P S _i^2$
Parameter	The parameter P used in the monitor and auxiliary spectrum averaging. For LINEAR averaging when P spectra have been computed and averaged, the monitor and auxiliary spectra become static and are not recomputed until the RESET special function key is pressed.
1	
2	
4	
8	
16	
32	
64	
128	
256	
512	
1024	
2048	
ALL	ALL causes new data to be disregarded for EXPONENTIAL averaging. For LINEAR averaging, ALL allows averaging to continue indefinitely without halting. RESET is still available to discard the accumulated average and start a new average.

<u>Menu Parameter</u>	<u>Comments</u>
Test Modification	
REFERENCE	Modify reference spectrum
AUX CHANNEL	Reassign auxiliary channel.
DRIVE UPDATE	Disable or re-enable drive update.
CURSOR LIMIT	Set frequency range cursors for display expansion and reference spectrum modification.

3.3 SETUP FUNCTION

To initiate the setup function, press MENU, set the function parameter to SETUP, and press EXECUTE.

The setup function defines test parameters that establish the conditions for a particular vibration test. A test specification or other guidelines for a test of the external load is usually the source of the test parameters. The setup function consists of an interactive dialog between the RANDOM program and you. Setup can be initiated any time the system is in standby to perform the four setup tasks: enter new parameters, modify previously entered parameters, list the parameters, or save the parameters on disk. It is not necessary to connect the system to an external load to execute the setup function.

Figure 3-3 shows the order in which the setup tasks are performed. Note the presence of a loop in the task flow. Following completion of the list task the program returns to the correction task. This loop allows you to conveniently make changes to the parameters, list the parameter set to inspect the changes, make additional changes, and so on. When the program exits from the setup function it sets the menu active. This is the typical action when a function terminates and is done because you usually wish to select another program function from the menu (loop check, test, etc.) immediately after the completion of the previous function.

Figure 3-4 shows a typical setup function dialog. Figure 3-5 is a listing of the parameters entered in Figure 3-4, showing how the program adjusts your input. In both these figures your responses are underlined. These parameters are also the load-time setup parameters as well as Receiving Checkout Test parameters used in Section IV.

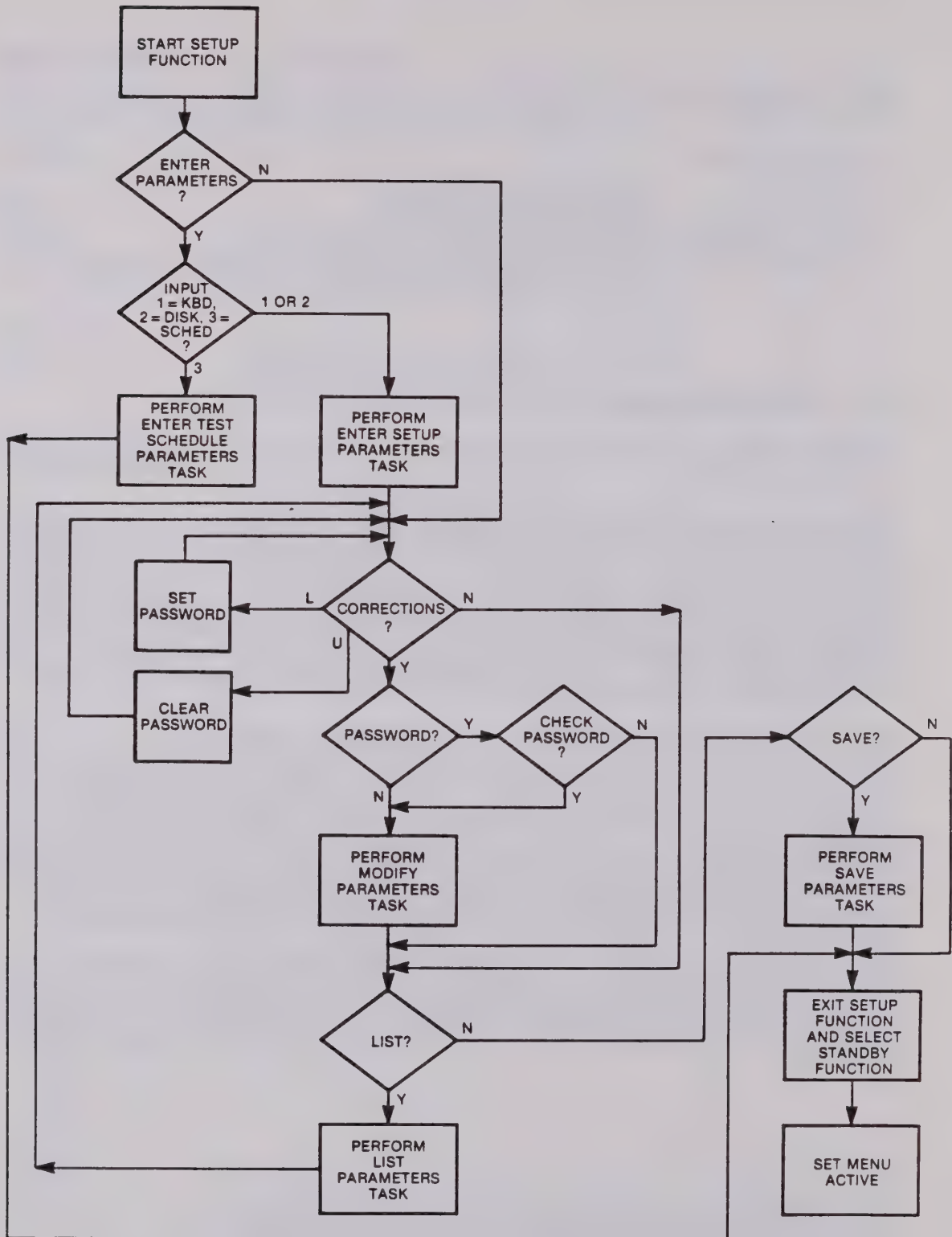


Figure 3-3. Setup Function Task Order

Enter Parameters? (Y/N): Y
 Input 1=Kvbd, 2=Disk, 3=Schedule: 1

1 Test Id: GR2511
 Comments: RANDOM VIBRATION CONTROL
 2 Heading: RECEIVING CHECKOUT TEST PARAMETERS

3 Bandwidth: 2000
 Bandwidth: 2000

4 Resolution 100/200/400/600/800: 200
 Frequency Increment (Hz): 10.00

5 Equalization Parameters
 Frames/Loop (Current Value=4): 4
 Discount Exponent (Current Value=3): 3
 Fast Initial Equalization? (Y/N): N

Reference Spectrum

6 Initial Slope (dB/oct): 6
 Alarm Limits (+dB, -dB): 6, -6
 Abort Limits (+dB, -dB): 20, -20

7 Frequency (Hz): 350
 Level (Gser/Hz): .01
 Alarm Limits (+dB, -dB): ^U
 Abort Limits (+dB, -dB): ^U

8 Frequency (Hz): 790
 Level (Gser/Hz): .01
 Alarm Limits (+dB, -dB): ^U
 Abort Limits (+dB, -dB): ^U

9 Frequency (Hz): 960
 Level (Gser/Hz): .001
 Alarm Limits (+dB, -dB): ^U
 Abort Limits (+dB, -dB): ^U

10 Frequency (Hz): 1375
 Level (Gser/Hz): .001
 Alarm Limits (+dB, -dB): ^U
 Abort Limits (+dB, -dB): ^U

11 Frequency (Hz): 1590
 Level (Gser/Hz): .01
 Alarm Limits (+dB, -dB): ^U
 Abort Limits (+dB, -dB): ^U

12 Frequency (Hz): 1760
 Level (Gser/Hz): .01
 Alarm Limits (+dB, -dB): ^U
 Abort Limits (+dB, -dB): ^U

13 Frequency (Hz): ^D

13 Final Slope (dB/oct): -48

Gras=3.194

14 Alarm/Abort Range

Low Free (Hz), High Free (Hz): 40, 2000

Lines to Trigger Alarm: 1

Lines to Trigger Abort: 1

15 Alarm Level (Gras): 4.8

Abort Level (Gras): 5

16 Low Level (-dB): -20

17 Auto Start? (Y/N): N

18 Level Increment (dB): 2

19 Start-up Time (sec): 1

20 Shut-down Time (sec): 1.5

21 Test Time (hr, min, sec): 0, 2, 0

22 Level Scheduling? (Y/N): N

23 16-Ch Selector? (Y/N): N

24 Control Channels: 1

25 Extremal Control? (Y/N): N

26 Auxiliary Channel: 0

27 Accel Sens (mV/g): 0

Ctrl Ch 1: 200

28 Prestored Drive? (Y/N): N

29 Drive Clipping? (Y/N): N

30 Automatic Mode Only? (Y/N): N

31 Spectra Storage? (Y/N): N

32 Loop-Check Max Drive (Volts): .1

33 AC Coupling? (Y=AC/N=DC): Y

34 Alarm Lines: 0

Abort Lines: 0

Corrections? (Y/N/L/N): Y

Line #: 27

Accel Sens (mV/g): 0

Ctrl Ch 1: 100

Line #: 0

List? (Y/N): N

Save Parameters? (Y/N): N

Figure 3-4. Typical Setup Function Dialog with Operator Entered Parameters

Enter Parameters? (Y/N): N

Corrections? (Y/N/L/U) N

List? (Y/N): Y

1 Test Id: GR2511

Comments: RANDOM VIBRATION CONTROL

2 Heading: RECEIVING CHECKOUT TEST PARAMETERS

3 Bandwidth: 2000

4 Resolution 100/200/400/600/800: 200.0

Frequency Increment (Hz): 10.00

5 Equalization Parameters

Frames/Loop: 4

Discount Exponent: 3

Fast Initial Equalization? (Y/N): N

Reference Spectra

6 Initial Slope (dB/oct): 6.000

Alarm Limits (+dB,-dB): 6.000,-6.000

Abort Limits (+dB,-dB): 20.00,-20.00

7 Frequency (Hz): 350.0

Level (Gser/Hz): .01000

Alarm Limits (+dB,-dB): 6.000,-6.000

Abort Limits (+dB,-dB): 20.00,-20.00

8 Frequency (Hz): 790.0

Level (Gser/Hz): .01000

Alarm Limits (+dB,-dB): 6.000,-6.000

Abort Limits (+dB,-dB): 20.00,-20.00

9 Frequency (Hz): 960.0

Level (Gser/Hz): .001000

Alarm Limits (+dB,-dB): 6.000,-6.000

Abort Limits (+dB,-dB): 20.00,-20.00

10 Frequency (Hz): 1370

Level (Gser/Hz): .001000

Alarm Limits (+dB,-dB): 6.000,-6.000

Abort Limits (+dB,-dB): 20.00,-20.00

11 Frequency (Hz): 1590

Level (Gser/Hz): .01000

Alarm Limits (+dB,-dB): 6.000,-6.000

Abort Limits (+dB,-dB): 20.00,-20.00

12 Frequency (Hz): 1760

Level (Gser/Hz): .01000

Alarm Limits (+dB,-dB): 6.000,-6.000

Abort Limits (+dB,-dB): 20.00,-20.00

13 Final Slope (dB/oct): -40.00

Gras=3.194

14 Alarm/Abort Range

Low Free (Hz), High Free (Hz): 40.00,2000

Lines to Trigger Alarm: 1

Lines to Trigger Abort: 1

15 Alarm Level (Gras): 4.000

Abort Level (Gras): 5.000

16 Low Level (-dB): -20.00

17 Auto Start? (Y/N): N

18 Level Increment (dB): 2.000

19 Start-up Time (sec): 1.000

20 Shut-down Time (sec): 1.500

21 Test Time (hr, min, sec): 0,2,0

22 Level Scheduling? (Y/N): N

23 16-Ch Selector? (Y/N): N

24 Control Channels: 1

25 Extremal Control? (Y/N): N

26 Auxiliary Channel: 0

27 Accel Sens (gUs):

Ctl Ch 1:100.0

28 Prestored Drive? (Y/N): N

29 Drive Clipping? (Y/N): N

30 Automatic Mode Only? (Y/N): N

31 Spectra Storage? (Y/N): N

32 Loop-Check Max Drive (Volts): .1000

33 AC Coupling? (Y=AC/N=DC): Y

34 Alarm Lines:

Abort Lines:

Corrections? (Y/N/ L/U) N

List? (Y/N): N

Save Parameters? (Y/N): N

Frequencies, setup time, and shutdown time are automatically adjusted to be integral multiples of the frequency increment or the frame acquisition time.

Figure 3-5. Listing of Parameter Set Formed in Figure 3-4

3.3.1 Special Responses in Setup Dialog

- CTRL/U** This character is formed by pressing the CTRL and U keys simultaneously and is printed as ^U. CTRL/U may be used in responding to ALARM LIMITS, ABORT LIMITS and FREQUENCY questions in defining the reference spectrum (paragraph 3.3.4.7, 3.3.4.8 and 3.3.4.9). A CTRL/U response means "same as the last-entered value for this parameter." For example, if a series of responses to repeated questions for the same parameter type are
- 5, CTRL/U, CTRL/U, 0, CTRL/U, 3, CTRL/U,
- the values assigned by the program will be
- 5, 5, 5, 0, 0, 3, 3.
- CTRL/D** Formed by pressing the CTRL and D keys simultaneously and printed as ^D. CTRL/D may be used as an alternate to a "0" (zero) response to the frequency question to terminate break-point definition for the reference spectrum. In defining a level profile test (paragraph 3.3.4.22) CTRL/D must be used in response to a level question to terminate level definition. Likewise, CTRL/D must be used to terminate new test schedule entries (paragraph 3.3.8.5). A CTRL/D response for these cases means "end of input list."
- STATE, C** This consists of two separate keystrokes, the STATE key followed by the C key. These two keystrokes act as a toggle switch between upper case and lower case alphabetic characters. Lower case characters may be used in yes/no responses (see below) or in entering the test header and test comments parameters (paragraph 3.3.4.1).
- Response to Y/N Questions** Several alternate responses are allowed to all questions that request a Y/N (yes/no) response. The alphabetic responses may be either upper or lower case (but may not be mixed upper and lower case). To answer in the affirmative, any of the responses YES, YE, Y, yes, ye, y, or 1 may be used. To answer in the negative, any of the responses NO, N, no, n, or 0 (zero) may be used. In the following paragraphs only the Y and N responses are indicated, but any of the alternate responses given here is acceptable.
- BACKSPACE** To correct an error or a mis-typed character, press the BACKSPACE key. This deletes the last character entered. Repeated backspaces may be used to delete more than one character or an entire response. If an error is not noticed until after a response has been completed, the BACKSPACE is not effective. In this case, continue through the setup dialog and then correct the erroneous parameter (via CORRECTIONS: (Y/N)? Y, LINE #, etc.).

RETURN	All responses except CTRL/U and CTRL/D must be terminated by pressing the RETURN key. A response is not complete and acted upon until the RETURN key is pressed.
Illegal responses	An illegal response to a setup question is rejected and the question is repeated until a legal response is entered.
ABORT	The ABORT key may be used to terminate parameter entry from the keyboard and return the program to standby. Use of ABORT for this purpose is discouraged unless you intend to re-enter the complete parameter set and does not intend to correct the existing parameters in memory. This is because when ABORT is used to terminate parameter entry, it is not possible to correct parameters with line numbers higher than the last line number entered from the keyboard before the ABORT key was pressed. See also paragraphs 3.3.4 and 3.3.5.

3.3.2 ENTER PARAMETERS? (Y/N):

This is the initial question in the setup dialog. Respond with Y to enter a new set of parameters into the system memory. Respond with N if you do not want to enter new parameters.

If the response is N, go to paragraph 3.3.5 to modify parameters if desired.

If the response is Y, the following statement occurs:

INPUT 1=KYBD, 2=DISK, 3=SCHEDULE:

Respond with 1 to enter a new set of parameters by your input from the keyboard. Go to paragraph 3.3.4.

Respond with 2 to load a set of parameters from a setup file previously saved on disk. Go to paragraph 3.3.3.

Respond with 3 to form a test schedule file. A separate "enter parameters" dialog will occur that allows you to create, save, modify, etc. a test schedule. Following completion of the test schedule dialog the program exits from setup and sets the menu active. Go to paragraph 3.3.8 to perform the test schedule dialog.

3.3.3 2=DISK

The program requests the name of a setup file from which setup parameters are obtained, via the message

TEST ID:

Respond with the one to six character filename of the file to be retrieved. This filename is the test ID that was assigned to the saved setup file in the first setup line when the parameters were entered. The program then prints

SYSTEM DEVICE UNIT NUMBER:

Respond with the unit number of the disk that contains the file. The unit number may be 0, 1, 2, or 3 depending on the disk hardware present in the system. NOTE: the program searches for the setup file on the same disk type the disk on which the operating system resides. The disk on which the operating system is resident is called the system device. The type of this disk (e.g., floppy disk, Winchester, etc.) is the system device type.

If the filename cannot be located on the specified disk unit the following statements are output:

FILE NOT FOUND
INPUT 1=KYBD, 2=DISK, 3=SCHEDULE:

Respond with 2 and begin again at the start of paragraph 3.3.3

If the filename is located it is then read into memory. If control menu parameter values and spectra were saved as part of the file, the menu values and spectra read from the file replace the values and spectra previously in memory. The optional password that locks the line editor will be current.

Two possibilities now exist, depending on the contents of the retrieved file. When the file was saved on disk you had the option of saving just the setup parameters, or the setup parameters plus certain spectra that were in memory at that time (see paragraphs 2.9.1 and 3.3.7).

- a. If the retrieved file consists of parameters only, go to c.
- b. If the retrieved setup file includes spectra, the following statement occurs:

MOVE MONITOR PSD TO REFERENCE? (Y/N):

Respond with Y to move a copy of the monitor spectrum retrieved as part of the setup file to the reference spectrum storage area. (This action is part of the Control to Measured PSD feature. See paragraphs 2.4.5 and 3.8.) The program outputs the message

ENTER NEW PARAMETERS

Go to paragraph 3.3.4.1 to begin keyboard entry of parameters. Note however that since the Control to Measured PSD feature is active, the following setup parameters are not available for definition or modification: bandwidth, resolution, initial and final slope decibel per octave values, and breakpoint levels. In this case these parameters are displayed but otherwise skipped over in the setup dialog. See also paragraph 3.8.

Respond with N to suppress moving the monitor spectrum to the reference spectrum area. Two additional possibilities now exist.

If the retrieved file contains a reference spectrum that itself was developed by use of the Control to Measured PSD feature, the program outputs the following statement:

MEASURED PSD STILL ACTIVE

This message is to inform you that the reference is not generated from the slopes and breakpoints contained in the parameter set. Continue with c.

If the retrieved reference spectrum did not result from the Control to Measured PSD process, continue with c.

- c. The entry of setup parameters from disk is now complete. The program outputs the following statements using information from the loaded parameter set:

```
TEST ID: xxxxxx
COMMENTS: xxx. . . . xxx
HEADING: xxx . . . . . xxx
GRMS=xxxx
```

Go to paragraph 3.3.5 to modify parameters if desired.

3.3.4 1=KYBD

The individual setup parameters are entered from the keyboard in this portion of the setup function dialog, as described in the following paragraphs 3.3.4.1 through 3.3.4.36. Each parameter or parameter group is assigned a line number by the program as shown in Figures 3-4 and 3-5. The line numbers are used to identify parameters to be modified. Line numbers 1 through 7 always refer to the same parameters. Higher line numbers depend on the number of breakpoints defined for the reference spectrum, and so may refer to different parameters in each parameter set. When modifying parameters, first list the parameter set in order to positively identify the line number of each parameter to be corrected.

If the ABORT key is used to terminate keyboard entry of parameters, you cannot correct parameters with line numbers higher than the last line number entered before entry was ABORTed. See also paragraph 3.3.5.

3.3.4.1 TEST ID:

COMMENTS:

HEADING: The test ID, comments, and headings are used to identify a particular set of parameters. These quantities appear as part of such displays as the post-test message and the spectrum display. The value supplied for the TEST ID is used as the filename if the parameter set is stored as a file on disk.

Respond to TEST ID with 1 through 6 alphanumeric characters (upper-case A through Z, 0 through 9). No spaces may be used.

Respond to COMMENTS with up to 47 characters. Any keyboard character may be used.

Respond to HEADING with up to 52 characters. Any keyboard character may be used.

Input to the comments and heading parameters may include upper and/or lower case alphabetic characters. The two-keystroke sequence STATE, C is available as a toggle between upper and lower case.

In addition, the left and right ARROW keys and the MARK key are available for use in editing the comments and heading parameters. Pressing either of the ARROW keys moves the point-of-type cursor in the corresponding direction within the existing, already entered character string, to position the cursor to a point where some change or addition is to be made. The MARK key terminates the parameter entry process and accepts the entire character string, regardless of the location of the point-of-type cursor.

The RETURN key has a special action when used to terminate the comments or heading parameters. The RETURN key causes the character string to be accepted up to the current location of the point-of-type cursor. Any characters at or beyond the cursor are excluded.

3.3.4.2 BANDWIDTH: Respond with one of the seven legal control bandwidth values. These values (in Hz) are as follows:

200
500
1000
2000
3000
4000
8000

The desired bandwidth is usually specified by the maximum frequency prescribed in the test specification governing the vibration test. If the selected bandwidth is not one of the above six values but does not exceed 8000 (Hz), the program does not reject the response but automatically selects the next higher legal value. If the required maximum frequency falls between two legal bandwidth values, select a final slope for the reference spectrum (see paragraph 3.3.4.10) that results in a suitable signal level at the maximum frequency.

8000 Hz is not selectable with 100, 200, or 600 lines of resolution. If the bandwidth is changed to 8000 Hz via the CORRECTION task and 100 or 200 lines is currently selected, the program rejects the correction and prints the message

NO 8KHZ FOR 100/200/600 LINES

See paragraph 3.3.5 regarding modification of the BANDWIDTH parameter via the setup CORRECTIONS procedure.

3.3.4.3 RESOLUTION 100/200/400/600/800: Respond to RESOLUTION with one of the five following legal values:

100
200
400
600
800

These values are the number of frequency lines to be calculated for each of the spectra generated by the program. This number of lines is the quantity M_f identified in paragraph 2.5.2 that determines the resolution of the spectra. The speed and accuracy of equalization is affected by the choice of M_f .

The values 600 and 800 may be selected only if the system includes at least 64K words of memory. If only 32K words are present the setup statement is modified automatically to be

RESOLUTION 100/200/400

and only the three values in the message are legal responses.

The parameter combination 8000 Hz bandwidth and 100 or 200 lines of resolution is not selectable. If this combination is chosen either during ENTER PARAMETERS or CORRECTIONS the message

NO 8KHZ FOR 100/200/600 LINES

is output and the RESOLUTION query is repeated.

The interval in Hertz between adjacent spectral lines, called the frequency increment, is automatically computed by the program as $BANDWIDTH/RESOLUTION$. The program outputs the computed value of this quantity to the CRT via the message

FREQUENCY INCREMENT, HZ = xxxx

If the BANDWIDTH or RESOLUTION parameters are modified via the parameter correction task, the program automatically recomputes and outputs a new FREQUENCY INCREMENT value (and a new GRMS value; see paragraph 3.3.4.11).

If 600 or 800 lines of resolution are selected, the data storage feature is not available due to lack of memory space and the following message is printed to inform you.

NO DATA STORAGE FOR 600/800 LINES

If the bandwidth value of a parameter set is being modified to 600 or 800 lines, and if data storage is currently selected, the new selection (600 or 800) is rejected and the same following message is output to indicate the parameter conflict. Selection of 600 or 800 lines is not accepted unless the parameter set is modified to deselect data storage.

See paragraph 3.3.5 regarding modification of the RESOLUTION parameter via the setup CORRECTIONS procedure.

3.3.4.4 EQUALIZATION PARAMETERS**FRAMES/LOOP (CURRENT VALUE=4):****DISCOUNT EXPONENT (CURRENT VALUE=3):**

FAST INITIAL EQUALIZATION? (Y/N): The FRAMES/LOOP quantity is the equalization parameter N, and the DISCOUNT EXPONENT is the equalization parameter K. These parameters are described in paragraphs 2.3.4 and 2.5.2. The load-time values of these parameters are N=4 and K=3; it is seldom necessary to modify these parameters to perform most vibration tests.

Respond to FRAMES/LOOP with 4 to retain the current value of N. If it is necessary to modify N, enter the appropriate number.

Respond to DISCOUNT EXPONENT with 3 to retain the current value of K. If it is necessary to modify K, enter the appropriate number.

At the start of a test, the initial drive signal level is below low level, and increases to low level during the initial loops of the test. The response to the FAST INITIAL EQUALIZATION query affects the time required for the drive signal to reach low level. A longer and more gradual increase to low level prevents shaker overshoot, which can occur due to a non-linear response by the shaker to changes in the drive level. However this more gradual drive signal increase results in a longer time to attain equalization at low level. Alternately, if the drive signal reaches low level more quickly, equalization is correspondingly more rapid. This is advantageous for use with shakers that have a more linear response to drive signal level changes.

Respond to FAST INITIAL EQUALIZATION with N to select a longer time for the drive signal to reach low level.

Respond with Y to select a shorter time for the drive signal to reach low level.

3.3.4.5 REFERENCE SPECTRUM. No response is necessary to this message. The reference spectrum is defined by your entry of its initial slope, breakpoint frequencies and levels, and final slope. The values to specify for each of these parameters are usually taken from a test specification for the external load. The parameter values are entered individually for each slope and breakpoint as described below in paragraphs 3.3.4.6 through 3.3.4.10.

3.3.4.6 INITIAL SLOPE (DB/OCT): Respond with a positive or negative number. Both the initial and final slopes are expressed in decibels per octave and may be either positive or negative slopes. If neither plus nor minus is specified the system assumes a positive slope. The initial slope defines a line that terminates at the first breakpoint of the reference spectrum. Where this line crosses the vertical axis determines the test level for 0 Hertz. A final slope is specified later, to provide a cutoff at the maximum frequency or merely to terminate the reference spectrum.

Note: Do not specify a slope of 0 for both the initial and the final slopes. The program uses that combination as a flag for a special purpose when it is writing and reading disk files of saved setup parameters and spectra in conjunction with the control-to-measured PSD function. If there is a need to define a reference spectrum that has both initial and final slopes of 0, artificially create the 0 final

slope by specifying a final breakpoint at the maximum bandwidth frequency that has the same level as the preceding breakpoint. Then enter an arbitrary non-zero number for the final slope, which is now outside the control bandwidth and therefore does not affect the reference spectrum. This procedure prevents confusion between defined and measured reference spectra when retrieving disk setup files.

3.3.4.7 ALARM LIMITS (+DB, -DB):

ABORT LIMITS (+DB, -DB): Alarm and abort limits in +dB (above) and -dB (below) may be specified for each slope and breakpoint parameter of the reference spectrum (see paragraph 3.2.3). The ALARM LIMITS and ABORT LIMITS statement therefore occur for each reference spectrum parameter. The +dB and -dB values for a given parameter can be different. If alarm or abort limits for a particular parameter are to be identical to those entered for the preceding parameter, they may be entered by pressing CTRL/U instead of retyping them. The alarm limits may be shown on the spectrum display as the alarm tolerance bands. The abort limits cannot be displayed.

Respond to each of the ALARM LIMITS and ABORT LIMITS statements with either (a) a positive number, followed by a comma, followed by a negative number, or (b) with a CTRL/U. A response of 0,0 causes limits to be undefined for that slope or breakpoint parameter. Therefore, if no alarm (or abort) limits are desired, respond with 0,0 to the ALARM (or ABORT) limits statement for all reference spectrum parameters. Values entered should satisfy the following relationships:

$$\text{ABORT (-DB)} \leq \text{ALARM (-DB)} \text{ and } \text{ALARM (+DB)} \leq \text{ABORT (+DB)}$$

The alarm tolerance limits are active at all times following the first six loops of a test, during which time equalization is first achieved (see paragraph 3.2.3). If the alarm limits are triggered the program sounds an audible alarm and displays the message

NO. OF ALARM LINES = X

in the message block area of the spectrum display, to alert you.

The abort tolerance limits also become active following the first six loops of a test, but are not active after the reference spectrum has been modified during a running test. If the abort limits are triggered the program sounds an alarm, displays the message

TEST ABORTED — SEE POST TEST

and returns to standby. The post-test message includes the statements

GSQR/HZ LIMITS EXCEEDED
FREQ (HZ) ERR (DB)

followed by a list of the frequencies and dB values where the abort limits were exceeded.

3.3.4.8 FREQUENCY (HZ): This statement is repeated for each breakpoint in the reference spectrum. At least one breakpoint must be defined. A maximum of 40 breakpoints may be defined. The reference spectrum modification can be used to create a spectrum that cannot be formed with only 40 breakpoints (see paragraph 3.5.6.1). Each two adjacent breakpoints define a straight line between them on a log-log scale. The program automatically adjusts each selected breakpoint frequency to be an integral multiple of the FREQUENCY INCREMENT if the entered value is not such a multiple.

Respond to FREQUENCY either with CTRL/U, with a positive value in Hz, or with 0 (zero) or CTRL/D. The first breakpoint serves as an end point for the initial slope, and its frequency value must equal or exceed the frequency increment. Successive breakpoint frequencies must be at least one frequency increment apart.

If the BANDWIDTH or RESOLUTION parameters are modified via the parameter correction task, the program automatically re-calculates the frequency increment and re-adjusts the breakpoint frequencies as required to be multiples of the new increment value.

The setup dialog follows one of the three alternatives given below depending on your response. (For additional information regarding breakpoint definitions see paragraph 2.4.9.).

1. A CTRL/U response to FREQUENCY defines a slope-type breakpoint. In this case the following query displays:

SLOPE (DB/OCT):

Respond with a positive or a negative number to specify the slope. If the definition is valid, control goes to paragraph 3.3.4.9 to complete entry of the breakpoint parameters.

If the response to SLOPE is 0 (zero), or if you attempt to generate a slope-type breakpoint via the parameter correction task, the program rejects the slope response and repeats the FREQUENCY query. A slope breakpoint is allowed only when the entire parameter set is entered.

The first and last breakpoints in the reference spectrum may not be defined as slopes, and a slope breakpoint may not be defined adjacent to another similar breakpoint. If either of these conditions is violated the message

<TWO CONSECUTIVE SLOPES NOT ALLOWED>

displays and the FREQUENCY query repeats.

2. If the response to the FREQUENCY query is a positive value (in Hz) that is less than or equal to the BANDWIDTH, a frequency-and-level type breakpoint is defined. In this case the following query displays.

LEVEL (GSQR/HZ):

Respond to LEVEL with a positive value in G^2/Hz . These are the units for amplitudes of individual spectral lines (see paragraph 2.3.3).

Note: see paragraph 3.3.5 for the correction task procedure for adding, deleting, or modifying a frequency-and-break level breakpoint.

If the previous breakpoint was a slope type, the definition of its level and cross-over frequency takes place at this time. If the definition is made successfully the message <CROSSOVER FREQUENCY, HZ:xxx > displays and control goes to paragraph 3.3.4.9. If the breakpoint parameters supplied do not allow proper calculation of a cross-over frequency then the following messages are output:

```

<ERROR IN CROSS OVER CALCULATION >
<FREQUENCY CALCULATED BELOW/ABOVE xxx HZ>
3 = RE-ENTER FROM LINE n-2  <FREQ = xxx, LEVEL = xxx >
2 = RE-ENTER FROM LINE n-1  <SLOPE = xxx >
1 = RE-ENTER FROM LINE n    <FREQ = xxx, LEVEL = xxx >
0 = CONTINUE
?
```

Line number n refers to the setup dialog line number of the current breakpoint (the breakpoint following the slope-type breakpoint). Line numbers n-1 and n-2 refer respectively to the slope-type breakpoint, and to the previous breakpoint. The quantities in brackets are the parameter values currently defined for the three lines.

Enter 3 to return to line n-2, to redefine the reference spectrum starting with the breakpoint before the slope breakpoint.

Enter 2 to return to line n-1, to redefine the reference spectrum starting with the slope breakpoint.

Enter 1 to repeat line n to redefine the breakpoint following the slope breakpoint.

Enter 0 to continue. In this case the slope breakpoint is converted to frequency/level form with the same frequency and level as the previous breakpoint. The breakpoint can be changed by modifying line n-1 via the parameter correction task.

Note: if a breakpoint is modified it may be defined only as a frequency-and-level type; entry of a slope-type breakpoint via the corrections task is not allowed.

3. If the response to FREQUENCY is 0, CTRL/D, or a frequency greater than the BANDWIDTH, or after 40 breakpoints are defined, control goes to paragraph 3.3.4.10 to conclude the reference spectrum definition.

3.3.4.9 ALARM LIMITS (+DB, -DB):

ABORT LIMITS (+DB, -DB): These statements occur following the **FREQUENCY** and **LEVEL** statements as part of each breakpoint definition. For details see paragraph 3.3.4.7.

After responses to both **LIMITS** statements are made, the program returns to the **FREQUENCY** and **LEVEL** queries in paragraph 3.5.2.8. This sequence continues until either 40 breakpoints are defined or until you respond to a **FREQUENCY** statement with a value equal to the **BANDWIDTH**, at which time control passes to the **FINAL SLOPE** statement (see paragraph 3.3.4.10).

3.3.4.10 FINAL SLOPE (DB/OCT): Respond with a positive or negative number. The final slope is selected so as to define a particular level value for the reference spectrum at the maximum frequency (B) or merely to terminate the reference spectrum. See the explanation and Note in paragraph 3.3.4.6.

3.3.4.11 GRMS = xxxx. This statement does not require a response. Following your entry of the final slope, the program automatically computes the total energy of the reference spectrum in grms (see paragraph 2.3.3) and outputs the calculated value in this statement.

If the **BANDWIDTH**, **RESOLUTION**, or any slope or breakpoint parameter is modified, the program automatically recomputes and outputs a new **FREQUENCY INCREMENT** value and a new reference spectrum **GRMS** value.

3.3.3.12 ALARM/ABORT RANGE

LOW,HIGH FREQ: The first statement requires no response. Respond to the **LOW,HIGH FREQ** statement with a low frequency, followed by a comma, followed by a high frequency such that:

$$0 < \text{low frequency} < \text{high frequency} < \text{maximum frequency}$$

These low and high values define the frequency range over which the alarm and abort limits are enabled. If a spectrum value exceeds an alarm or abort limit outside of this frequency range, the out-of-tolerance condition is ignored and cannot cause an alarm or abort.

If the low and high frequency values entered are equal, the alarm and abort limits are disabled over the entire bandwidth.

3.3.4.13 LINES TO TRIGGER ALARM:

LINES TO TRIGGER ABORT: Respond to each statement with a positive value. These values define the number of out-of-tolerance spectrum lines (within the frequency range where the alarm/abort limits are enabled) that are required to trigger an alarm condition or an abort condition, respectively.

Note: These statements should not be confused with the statements in paragraph 3.3.4.36 that pertain to the external alarm and abort lines option.

3.3.4.14 ALARM LEVEL (GRMS):

ABORT LEVEL (GRMS): Do not confuse grms alarm and abort level with alarm and abort limits. Alarm and abort limits are expressed in dB for the initial slope and for each breakpoint frequency of the reference spectrum (see paragraphs 3.3.4.7 and 3.3.4.9). The grms alarm and abort levels are specified in grms for the overall acceleration of the entire control spectrum.

Respond to each of the ALARM LEVEL and ABORT LEVEL statements with a value (in grms). The values entered must be selected with regard to the reference spectrum grms value in the program generated statement GRMS=xxxx (see paragraph 3.3.4.11), and the maximum allowable acceleration level for the external load. The values should satisfy the following relationship:

$$\text{ref. spectrum grms} < \text{ALARM grms} < \text{ABORT grms} < \text{max. load grms}$$

If during any control loop of a vibration test, the grms level of the control spectrum exceeds the ALARM grms value, an audible signal occurs and the INPUT GRMS displayed in the summary area of the spectrum display (see paragraph 2.8.3 and Figure 3-2) is replaced by ALARM GRMS. The value following the ALARM GRMS message is the grms value of the current loop control spectrum that exceeded the alarm level. If the alarm condition persists for a number of loops, the audible tone and ALARM GRMS message repeats once each loop.

The ALARM and ABORT grms levels are active for both manual and automatic mode. If the control spectrum grms level exceeds the ABORT level in any loop, the program shuts down the test, displays the message

TEST ABORTED — SEE POST TEST

and returns to standby. The post-test message includes the statement

GRMS EXCEEDED!

as an indication of the condition that caused the abort.

3.3.4.15 LOW LEVEL (-DB): Respond with a negative number. This parameter specifies the initial level of the drive spectrum following the loop-check portion of a vibration test. Equalization of the external load first takes place when the drive signal is at low level. The test low level is specified relative to (i.e., a number of dB below) the test full level. The full level is automatically determined by the program from the reference spectrum and defined to be 0 dB. (See paragraphs 2.6 and 2.6.1.)

3.3.4.16 AUTO START? (Y/N): Respond with N to specify manual start. This choice causes the test to remain at low level until you press the ↑ key.

Respond with Y to specify auto start. This choice causes the program to maintain the drive signal at low level for a specified period of time, and then to automatically increase the level by one level increment (ΔL). The program displays the message

LOW LEVEL TIME (SEC):

Respond with a positive number to select the number of seconds the test is to stay at low level before the level is increased by ΔL .

3.3.4.17 LEVEL INCREMENT (DB): Respond with a positive number, to specify the magnitude of the change in test level that occurs each time the level is increased or decreased, either manually or automatically.

This parameter is the quantity ΔL in Figures 2-7 and 2-8 and paragraph 3.3.4.16. The value of this parameter determines the number of intermediate test levels between low level and full level. For example, if low level was selected as -20 dB and the level increment is chosen as 2 dB, the number of incremental levels is $(\text{full level} - \text{low level}) / \Delta L = 20 / 2 = 10$. The maximum possible value for ΔL is full level - low level, or 20 in this example. The program adjusts entered values for the level increment as follows:

- a. If a floating point number is entered, the value is truncated to the next lower integer, and
- b. If an excessively large value is entered, the value is automatically set to the maximum possible value of (full level - low level).

3.3.4.18 START-UP TIME (SEC): Respond with zero or a positive number. This parameter has effect only when the program is in automatic mode, and is ignored in manual mode. Automatic or manual mode is selected via the mode menu parameter (see paragraphs 2.6.3 and 2.10.3). In automatic mode the test level increases automatically to full level after the initial increase from low level. The start-up time parameter specifies the total time in seconds required to increase the test level to full level. The time spent at each of the incremental levels while increasing from low to full level is automatically calculated by the program as the start-up time divided by the number of incremental levels.

The special start-up time of 0 (zero) selects the minimum start-up time, where the time spent at each incremental level is the time required to output just one frame of the drive signal.

3.3.4.19 SHUT-DOWN TIME (SEC): Respond with a positive number, representing time in seconds. This parameter specifies the time in which the test level decreases to 30 dB below full level, when a test is shut down for any reason (including abort conditions or normal test completion).

3.3.4.20 TEST TIME (HRS, MIN, SEC): Respond with three non-negative numbers separated by commas, to specify the duration of the test. (For example, a response of 0,2,30 selects a test time of 0 hours, 2 minutes, and 30 seconds.) The test automatically initiates shutdown when the specified test time elapses.

The periods during a vibration test that count toward the test time depend on the type of level control selected for the test. Refer to the quantity shown as "(TEST TIME)" in Figures 2-7, 2-8, and 2-9.

For an unscheduled test, only the time during which the test is at full level counts toward the test time. Further, if the test is run in manual mode and you decrease the test level from full level, the time spent below full level does not contribute towards the test time.

For a level profile test, all time after the test leaves low level counts toward the test time. For a level cycle test, all time after the test initially reaches full level (in the unscheduled portion of the test) counts towards the test time. Since manual mode is not allowed for level scheduling, you cannot manually decrease the test level below full level for a level profile or level cycles test.

3.3.4.21 LEVEL SCHEDULING? (Y/N): Respond with N to select unscheduled test level control (see Figure 2-7) and paragraph 3.3.4.25.

Respond with Y to select level scheduling. The program outputs the message

1=PROFILE, 0=CYCLES

Respond with 1 to select level profile. Go to paragraph 3.3.4.22.

Respond with 0 to select level cycles. Go to paragraph 3.3.4.24.

If level scheduling is selected the program is required to operate in automatic mode (see paragraph 2.7.3). While a parameter set with level scheduling selected is in the system memory, the mode parameter in the control menu can be set to MANUAL but this setting is ignored and the program is actually in automatic mode.

3.3.4.22 N LEVEL (-DB):

TIME (HR, MIN, SEC): This pair of statements occurs for each level in the level profile. Up to 32 levels may be defined. The program assigns a number (N) to each statement pair. The number is used when changing the profile.

Respond to the LEVEL statement with a number representing the test level in dB (relative to full level) for level N of the profile. The value supplied must not exceed 0 (full level). However, drive update is automatically disabled for levels lower than -20 dB.

Respond to the TIME statement with three non-negative numbers, separated by commas, to specify the time in hours, minutes, and seconds that the test shall remain in level N.

After a response to the TIME statement is made, the LEVEL statement is repeated for the next (N+1) level. Respond as above until all desired levels have been defined. Then terminate the definition process by responding to the LEVEL message with CTRL/D. The program prints "LOOPS:". Respond with an integer greater than zero to set the number of times that the profile list is to execute. Continue with paragraph 3.3.4.23.

3.3.4.23 0=EXIT

1=LIST PROFILE

2=MODIFY PROFILE

3=ENTER NEW PROFILE

4=DELETE A LEVEL

5=INSERT A LEVEL

6=CHANGE # OF LOOPS

?

This program generated table indicates the options available to list or change the currently defined profile. Respond to the ? with one of the numbers 0 through 6, and proceed as shown in 1 through 6 below.

When the operations initiated by a response of 1, 2, 3, 4, 5, or 6 complete, the above table repeats so that another list or change operation can be chosen. This continues until a response of 0 is made to terminate the level profile dialog.

- 6=CHANGE NUMBER OF LOOPS

The program outputs the statement

LOOPS:

Respond with a number of times you want to run the level profile. The program rejects any number less than 1, and repeats the question.

- 5=INSERT A LEVEL

The program outputs the statement

INSERT AT LEVEL #

Respond with a number from 1 to the largest defined level number. If the response is M, the program outputs the following statements:

M LEVEL (-DB):

TIME (HR, MIN, SEC):

Respond as in paragraph 3.3.4.22 to define the new level. The level is inserted in the profile as the new level number M. The previous M level and any subsequent levels increments by one in the profile.

- 4=DELETE A LEVEL

The program outputs the statement

DELETE LEVEL #

Respond with a number from 1 to the largest defined level number. The program deletes the specified level and re-numbers all subsequent levels in the profile.

- 3=ENTER NEW PROFILE

Return to paragraph 3.3.4.22 to enter an entire new profile. This operation completely deletes the existing profile and replaces it with the new one.

- 2=MODIFY PROFILE

The program outputs the statement

LEVEL NUMBER:

Respond with a number from 1 to the largest defined level number. If the response is M, the program displays the following statements:

M LEVEL (-DB):
TIME (HR,MIN,SEC):

Respond as instructed in paragraph 3.3.4.22 to change the -dB and/or time values for level M. All other levels in the profile are unchanged.

- 1=LIST

A list of the levels in the profile is output in the following format:

LEVEL #	LEVEL (DB)	TIME(H,M,S)
1	xxxx	x,x,x
2	xxxx	x,x,x
3	xxxx	x,x,x
etc.		

- 0=EXIT

This response terminates the level profile portion of the setup dialog. The program outputs the message

TEST TIME (HRS, MIN, SEC): xx,xx,xx

giving the total time required for the test execution. This is the sum of the times of the individual levels in the profile, plus the transition time between each level, plus the transition time between the last level and the first level, all multiplied by the number of loops the profile is to run. The transition time between any two levels is rounded to the nearest second. For example, a 1.3 second transition time is added to the total time as 1 second, or a .7 second transition time is added to the total time as 1 second. The message does not require a response. Continue with paragraph 3.3.4.25.

3.3.4.24 LOW LEVEL (-DB):

DECAY TIME TO LOW (SEC):

TIME AT LOW (HR,MIN,SEC):

RISE TIME TO FULL (SEC):

TIME AT FULL (HR,MIN,SEC):

NUMBER OF CYCLES:

cycles test (see paragraph 2.6.5).

This group of statements defines a level

Respond to LOW LEVEL with a number specifying the cycle low level (in dB) for the test. The value must be less than 0. The drive update is automatically disabled for levels lower than -20 dB.

Respond to DECAY TIME with a number specifying the transition time (in seconds) from full level to cycle low level.

Respond to TIME AT LOW with three numbers separated by commas, giving the time (in hours, minutes, and seconds) that the test is to remain at cycle low level in each cycle.

Respond to RISE TIME with a number specifying the transition time (in seconds) from cycle low level back to full level.

Respond to TIME AT FULL with three numbers separated by commas, giving the time (in hours, minutes, and seconds) the test is to remain at full level in each cycle.

Respond to NUMBER OF CYCLES with a number defining the number of cycles in the test.

After responses have been made to all of the above statements the program outputs the message

TEST TIME (HRS, MIN, SEC): xx,xx,xx

giving the total time defined for the test execution. This time is equal to the quantity (decay time + time at low + rise time + time at full) multiplied by the number of cycles.

3.3.4.25 16-CH SELECTOR? (Y/N): Respond with N if the 16-channel selector hardware is not present in the system, or if it is present but not used in the test being set up.

Respond with Y if the optional selector hardware is present and is to be used. Before executing a test using the selector, all control and auxiliary signal inputs must be connected to selector connectors 1 through 16. These inputs are identified in the response to the CONTROL CHANNELS and AUXILIARY CHANNEL queries (see paragraphs 3.3.4.26 and 3.3.4.28). The SELECTOR OUTPUT connector of the 16-channel selector unit must be connected to the input of ADS channel 1 (A). Do not use other ADS inputs.

3.3.4.26 CONTROL CHANNELS: The control channels are the input channels through which signals from accelerators on the external load enter the system. Standard systems have a single ADS channel, named channel 1 or A. Additional input channels can be provided by adding up to three more ADS channels (2-4 or B-D), or by adding the 16-channel selector.

Respond with a series of positive numbers separated by commas, where each number represents a channel on which a signal is to be input to the system. If the response to the 16-CH SELECTOR query is N, the maximum legal channel number is equal to the number of ADS channels present in the system (1 to 4). If the response to 16-CH

SELECTOR is Y, the maximum legal channel number is 16 and the numbers entered refer to input numbers on the 16-channel selector unit (see paragraph 2.12).

During test execution the system controls the external load using inputs from all designated control channels. At least one channel must be specified. If more than one channel is entered, the order of the channel numbers is not significant. Duplicate channel numbers may be supplied, and the duplications are significant as shown in the following example.

If the response to CONTROL CHANNELS is 1,1,1,2,3, then during each loop the system computes three PSDs for channel 1, and one PSD for each of channels 2 and 3. The averaged control spectrum computed from these PSDs thus biased towards the channel 1 input (3 out of 5 PSDs, or 60%) as opposed to input from channels 2 and 3 (1 out of 5 PSDs, or 20% each). Duplicate channel numbers are thus used to cause the system to give more emphasis to certain points on the test structure. Do not do this if it is not required since the loop time varies directly with the total number of control channels specified and duplicate numbers count toward the total.

3.3.4.27 EXTREMAL CONTROL? (Y/N): Respond with N to reject extremal control and select linear averaging of the control channels specified in paragraph 3.3.4.26. (For linear averaging, the value of the spectral line for each frequency in the new control spectrum $|C|_N^2$ is calculated as the linear average of the lines for that frequency of the spectra for the individual control channels.)

Respond with Y to select extremal control. This is an alternate means of forming the control spectrum $|C|_N^2$. With extremal control, the spectra for the individual control channels are compared and the largest (extreme) value for each frequency is selected to be the value of the spectral line for that frequency in $|C|_N^2$.

Extremal control is allowed only if more than one control channel is defined. (With only one control channel defined, extremal averaging is identical to the default linear averaging case.) Therefore, if only one control channel is selected, the program generates not only the query but also an automatic N response and proceeds directly to paragraph 3.3.4.28. Similarly, if you modify a parameter set that specifies multiple control channels and extremal control so as to reduce the number of control channels to one, the program automatically deselects extremal control and generates the above query and N response as an indication that the deselection has taken place.

If extremal averaging is selected and allowed, the program outputs the messages

LIMIT FACTORS (DB)
CTL CH x:

The LIMIT FACTORS message does not repeat and does not require a response.

The CTL CH message repeats for each control channel (x) specified in paragraph 3.3.4.26. Respond to each CTL CH message with a scale factor in dB. A response of 0 leaves the control spectrum for the indicated channel unchanged. Responding with a positive value amplifies the spectrum for this channel by the specified number of dB; a negative value attenuates the spectrum. The scaling capability allows you to individually adjust the amplitude of each single channel spectrum (for example, to

compensate for peaks or notches) so as to allow the data from each channel to make a desired contribution to the extremal control spectrum.

The CTL CH x query repeats for each control channel specified in paragraph 3.3.4.26. After responses are entered for all such queries, the program continues to the next paragraph.

Note: the limit factors specified for the control channels must be selected with caution to avoid unintentional under-testing or over-testing of the test specimen. Over-testing can occur if all control channels are given a negative limit factor. To avoid over-testing, select a zero or positive limit factor for at least one control channel. If any positive limit factors are specified, under-testing can occur and there is no choice of compensating factors guaranteed to prevent under-test.

The composite control spectrum displayed via the CONTROL selection of the Display menu parameter, incorporates all limit factors and does not reflect the actual pre-limit response signals received from the external load. These signals are individually inspected by selecting each control channel in turn as the auxiliary channel (via the AUX CHANNEL menu parameter) and selecting the AUXILIARY channel for display. If the tolerance bands parameter is set to ON, the level of each signal with respect to the reference spectrum is determined. If any non-zero limit factors are selected you are advised to inspect each control channel by this means while the test is at low level at any control point on the external load, so as to prevent inadvertant testing at an unwanted level. While at low level the auxiliary spectrum is normally below the tolerance bands. The full test level conditions are predicted by picturing the auxiliary spectrum raised by an amount in dB equal to the |test level| item (5) in Figure 3-2. For example, if the test level on the display is -20 dB, the auxiliary spectrum should be pictured as being increased |-20| = 20 dB. At 10 dB per decade, this is equal to an increase of 2 decades on the display.)

3.3.4.28 AUXILIARY CHANNEL: The auxiliary channel may be specified as any one of the available input channels, whether or not the same channel is selected as a control channel. If multiple control channels are defined for a test, the control spectrum is a combination of response data from all control channels and so cannot be used to examine the response of any individual channel. To achieve this result, the auxiliary channel, which can be separately displayed, is defined as one of the control channels.

Respond with 0 or with a positive number that is the number of an input channel in use for this test.

A response of 0 means an auxiliary channel is not to be defined.

A positive response defines a channel number that is to be the auxiliary channel. If the 16-channel selector is not used, this number must be one of the ADS channel numbers (1 through 4) present in the system. If the selector is used for this test, the number may be in the range 1 through 16.

If the selected auxiliary channel is not also a control channel, the following queries occur:

MAXIMUM EXPECTED GRMS:
ACCEL SENS (MV/G):

Respond to the MAX GRMS query with a value (in grms) for the expected total energy of the spectrum to be computed from the auxiliary channel. This energy should not exceed the ABORT grms value entered in paragraph 3.3.4.14.

Respond to the ACCEL SENS query with a value in millivolts per g that represents the sensitivity of the analog input signal received on the auxiliary channel. (See also paragraph 3.3.4.29.)

Note: If the auxiliary channel is also selected as a control channel, the foregoing messages do not appear. In this case the control spectrum grms and sensitivity values take precedence. The reference spectrum grms value calculated by the program (see paragraph 3.3.4.11) is used as the expected control spectrum grms, and the accelerometer sensitivity for each control channel is supplied in paragraph 3.3.4.29.

The averaging parameters for the auxiliary channel are set using the Monitor/Auxiliary Avg menu parameters, and not via the setup function. During test execution the auxiliary spectrum is selected for display using the spectrum menu parameter. Menu parameters and the MODIFY special function key may be used to reassign the auxiliary channel to another input channel and to specify a new accelerometer sensitivity. See paragraph 3.5.6.2.

3.3.4.29 ACCEL SENS (MV/G)

CTL CH x: The ACCEL SENS message does not repeat and does not require a response. The CTL CH message repeats for each control channel (x) specified in paragraph 3.3.4.26. Respond to each CTL CH message with a value in millivolts per g representing the analog signal sensitivity for the indicated control channel.

Accelerometer sensitivities must be specified for all input (control and auxiliary) channels. For accurate control and displays the values entered for each channel must match the sensitivity of the analog input signal received on that channel. This sensitivity is usually determined from the characteristics of each accelerometer charge amplifier.

The program sets the ADS hardware input voltage range to a value that applies to all channels, based on the grms level of the reference spectrum and the specified accelerometer sensitivity for the first selected control channel as follows:

$$\text{Peak voltage} = (\text{ref. spectrum grms}) \times 4 \times (\text{1st ctl accel ch sens mV/g})$$

For example, if the reference spectrum grms level is 3.294 g and the sensitivity of the first control channel specified in paragraph 3.3.4.26 is 100 mV/g, then the expected peak voltage is $(3.294 \text{ g}) \times 4 \times (100 \text{ mV/g}) = 1.3176 \text{ volts}$. The ADS hardware would in this case be set to the next higher available voltage range, which is $\pm 2 \text{ volts}$.

There are two additional considerations regarding the selection of accelerometer sensitivities for control channels other than the first channel. These considerations apply because the single channel control spectra are combined to form $|C|_N^2$ and it is necessary to make the individual control signals comparable in magnitude. The following two points do not apply to the auxiliary channel if it is not also a control channel.

- The program scales all control signals relative to the first channel, by the ratio ($\text{sens}_1/\text{sens}_N$) where sens_1 and sens_N are the sensitivities for the first and N-th channels, respectively. For example, if sens_1 is 100 mV/g and sens_N is 250 mV/g, then the signal from the N-th control channel is scaled by 100/250 or 0.4.
- Control channels after the first should have sensitivities comparable to that of the first channel. Lesser sensitivities (lower mV/g values) could cause software clipping (input data value overflow) when the data is scaled. The program does not allow sensitivities of less than 70% of the first channel sensitivity. If you enter a value that violates this restriction the CTL CH x query repeats. The 70% value is chosen on the assumption that the input data peaks typically do not exceed three standard deviations from the mean of a random signal. The above formula for setting the input peak voltage allows for about four standard deviations, and 70% is safely less than 75%.

3.3.4.30 PRESTORED DRIVE? (Y/N): Respond with N if you do not wish to use a prestored drive. In this typical case, the program uses an attenuated copy of the reference spectrum as the initial drive spectrum. This choice is selected when there is no pre-test knowledge of the shape of the drive signal that is required to achieve equalization.

Respond with Y to select the prestored drive feature. This causes the program to use the drive spectrum currently in the system memory as the initial drive spectrum for the test.

Use of a prestored drive can be advantageous when consecutive tests are to be run on the same or similar external loads. In this case, use of the drive spectrum from the previous test results in faster equalization. The following procedure is used when running a series of tests on similar or identical test specimens:

- Run the first test using a parameter set that does not use prestored drive.
- At the end of the first test, change the setup parameters to select prestored drive.
- Then run the remaining tests. Each uses the drive spectrum from the previous test as the initial drive spectrum.

If you select prestored drive, the program outputs the message

CONFIRM AFTER START? (Y/N):

Respond with Y to cause the program to request your input and allow the prestored drive test to proceed when it is executed. Respond with N to bypass your input.

When a test that includes selection of prestored drive is executed, the program displays the message PRESTORED DRIVE ACTIVE in the message block area of the CRT.

If the CONFIRM question above was answered Y(es), the program outputs PROCEED? (Y/N) in the query block area of the CRT and waits for your response before continuing with the test. The drive spectrum displays for visual acceptance. This allows you an opportunity to determine that the desired drive spectrum is in memory before a drive signal is output to the external load. A response of Y to the PROCEED? query allows the test to continue. A response of N aborts the test and returns the program to standby. You may then retrieve a new drive spectrum from the disk or alter the setup parameters and re-run the test.

If the CONFIRM query is answered N(o), when the test is executed the message PRESTORED DRIVE ACTIVE displays on the CRT, but the program proceeds with the test without calling for your input.

3.3.4.31 DRIVE CLIPPING? (Y/N): Respond with N to bypass drive signal clipping. If clipping is not selected the program does not impose any ceiling on the magnitude of the drive signal frames calculated and output to the external load. Continue with paragraph 3.3.4.32.

Respond with Y to select drive signal clipping. The program outputs the following query:

TYPE (1=SIGMA, 0=VOLTAGE):

Respond with 0 to select voltage clipping. The system outputs the message

VOLTAGE LEVEL:

Respond with a number specifying an absolute value in volts that the level of the drive signal is not allowed to exceed. This voltage ceiling is applied to each drive signal frame output. The program truncates to the limit level any voltages in any frame that exceed the specified limit value.

Respond with 1 to select sigma clipping. The system displays the message

SIGMA LEVEL:

Respond with a number representing a multiple of the rms voltage of the drive signal. When sigma clipping is selected, the program computes the rms value of each drive signal frame. It then truncates any values in the frame that exceeds the specified multiple of the rms value.

Clipping is required for certain test specifications. However, clipping tends to increase the level of high frequency components in the drive signal.

3.3.4.32 AUTOMATIC MODE ONLY? (Y/N): Respond with N to allow selection of automatic or manual mode via the control menu mode parameter.

Respond with Y to disable manual mode and force the mode parameter to the AUTOMATIC setting.

See paragraph 2.6.3 for a description of automatic and manual modes. If manual start is selected in paragraph 3.3.4.16, a test run in automatic mode requires your action.

3.3.4.33 SPECTRA STORAGE? (Y/N): Respond with N if you do not want to store spectra during a test execution. The setup function continues with LOOP CHECK MAX DRIVE (VOLTS): (see paragraph 3.3.4.34).

Respond with Y if spectra are to be stored on disk during a test execution. The program outputs the query

1=AUTO-STORE, 0=MANUAL:

Respond with 1 to select automatic storage of spectra at regular intervals. If auto-store is chosen the program outputs

INTERVAL (SEC):

Respond with a value in seconds that specifies how frequently during a test that the spectra will be stored. Spectra is not stored more often than once per loop, even if the specified interval is less than the loop time of the test.

Respond with 0 to select manual storage of spectra. This option requires you to press the right-arrow (→) key whenever spectra are to be stored (but not more often than once per loop).

Either response is followed by

SYSTEM DEVICE UNIT NUMBER:

Respond with the unit number of the disk on which the spectra is stored. The disk must be the same type of device as the system device, i.e., the disk type on which the operating system resides. Also, spectrum storage is not allowed for 600 or 800 lines of resolution. If one of these resolution values has been specified and spectrum storage is selected, the program outputs the message

NO DATA STORAGE FOR 600/800 LINES

and rejects the spectrum storage selection.

3.3.4.34 LOOP CHECK MAX DRIVE (VOLTS): Respond with a value in volts specifying the maximum level for the drive signal that is output to the external load during the loop check performed at the start of a test. If the drive signal level reaches the loop check maximum and no threshold response is detected from an input channel, the program declares an open loop failure condition. The loop check maximum drive should therefore be selected high enough to generate a response signal.

A response of 0 (zero) causes the program to omit the loop check that is normally performed at the start of each test execution.

The loop check maximum drive used in the independent loop check function is specified separately (see paragraph 3.4).

If a loop check is desired (non-zero reply), the following question appears:

PRINT GAIN AND PAUSE AFTER LOOP-CHECK? (Y/N):

A Y (yes) response causes the system gains for each control channel to be printed after the LOOP OK message. You are allowed to return to standby or proceed with the test.

A N (no) response suppresses the gain calculation and messages.

3.3.4.35 AC COUPLING? (Y=AC,N=DC): Respond with Y to select ac coupling, respond with N to select dc coupling.

Selection of ac or dc coupling applies to input signals and does not apply to the drive signal. Selection of ac coupling causes the input signals to pass through circuitry that performs dc removal. Ac coupling is usually chosen for random vibration tests.

3.3.4.36 ALARM LINES:

ABORT LINES: These statements occur only if the remote communications option hardware is present in the system. This provides 16 input lines for remote control use in test scheduling operations and for external supplied alarm and abort signals (see also paragraph 2.9). Remote control use of these signals takes priority over alarm/abort use; if any line selected for an alarm or abort condition is also selected for a remote controlled test schedule operation, the selection for alarm or abort is ignored.

Respond to each statement with a series of numbers separated by commas, representing the line numbers (1 through 16) to be recognized for alarm or for abort use. A line may be used as an alarm condition or an abort condition, but not both.

A response of 0 to either statement is interpreted as to select no alarm lines or to select no abort lines.

If any alarm or abort lines are selected, the program outputs the message

RESPONSE (1=OPEN, 0=SHORT):

Respond with 1 to select an open circuit (10K ohms or greater) as the trigger condition for the lines.

Respond with 0 to select a closed circuit (100 ohms or less) as the trigger condition for the lines.

3.3.5 CORRECTIONS? (Y/N/L/U):

Respond with N if no corrections are to be made to the setup parameters just entered or retrieved from disk. Continue at paragraph 3.3.6 with the LIST operation.

Respond with Y to make corrections to the parameter set currently in memory. If the line editor is locked with a password, the program prints the message:

Password:

Enter the password and the program activates the line editor with the prompt LINE #:. (The program does not echo the typed characters when entering the password.) If you enter the wrong password, the program prints the message:

Invalid Password

The line editor is bypassed and control is transferred to the LIST operation (see paragraph 3.3.6).

If the line editor is unlocked, the program goes directly to the LINE #: prompt.

Respond with an L to lock the line editor. If the line editor is not locked, the program prompts you with the message:

Password:

Enter the password you want to use. You may enter up to 40 characters, though the program will recognize only the first 6. Any character on the keyboard can be used (except control or escape sequences). The program then prompts you to verify the password you entered by the message:

Verify Password

Password:

Enter the password you want to use to lock the editor, again. If the program finds that the two are the same, it saves the password and looks for this password until it is unlocked. Control returns to the CORRECTIONS question. If the program finds that the two passwords are not the same, the editor is not locked, and prints the message:

Invalid Password

Control returns to the CORRECTIONS question.

If the line editor is locked, the program prints the message:

Already Locked

and the CORRECTIONS question is repeated.

Respond with a U to unlock the line editor. The program prompts for the password and clears the lock, if the password you give matches the current password. If the password does not match, the program prints the message:

Invalid Password

and control is transferred to the LIST question (see paragraph 3.3.6).

If the editor is not locked, the program prints the message:

Not Locked

and the CORRECTION question is printed.

When the program outputs the message

LINE #:

Respond with the number of the line in the setup dialog that is to be modified. If the line to be corrected is one of a group of statements (only the first of which is numbered) enter the number of the first line in the group. Any invalid response to a LINE # query causes the program to terminate the CORRECTIONS task and advance to the LIST operation.

Note: If the ABORT key was used to terminate keyboard entry of parameters, it is not possible to correct line numbers higher than the last line number entered prior to the use of ABORT. Entry of a higher line number causes the correction process to be terminated, and the program advances to the LIST operation. The only way to alter the higher line number parameters is to re-enter them as part of a new keyboard entry (1 = KYBD) operation.

The program assigns the line numbers sequentially to the lines of the setup dialog. The total number of lines in the dialog depends on the number of breakpoints defined for the reference spectrum, so that the line number of a particular setup parameter varies from one parameter set to the next. If the line number of a parameter to be modified is not known, use the LIST feature to view the parameter set, note the line number in question and perform the correction.

Following the response to the LINE # message the program displays the statement for the parameter indicated by the entered line number.

Respond with the corrected value for the parameter. If the parameter to be changed is one of a group of statements, respond to each statement in the group including the one requiring modification.

When the modification is complete, the program repeats the

LINE #:

message to allow you to correct another parameter. Any number of parameters may be changed in this way. After all desired changes have been made, respond to the LINE # message with 0. The program then advances to the LIST operation in paragraph 3.3.6.

3.3.5.1 Editing COMMENTS and HEADINGS Parameters.

LINE #: 1 Line 1 edits the test ID and comments parameters.

LINE #: 2 Line 2 edits the header parameter.

The following special keys are available for use in correcting the COMMENTS and HEADINGS parameters:

The ← and → keys may be used to position the point-of-type cursor to a position in the comments or heading character string where a correction is to be made. New characters entered over-write existing characters in the string.

The STATE,C keystrokes act as a toggle between upper and lower case alphabetic characters.

The MARK key terminates the correction process and causes the entire current character string to be accepted, regardless of the location of the point-of-type cursor.

The RETURN key terminates the correction process and accepts the character string up to the location of the point-of-type cursor. Characters at or following the cursor are excluded.

3.3.5.2 Add or Delete Breakpoint. The following special responses to the LINE # query are provided to add or delete a breakpoint from the reference spectrum:

LINE # : n,-1 This response deletes the breakpoint that is line n of the set-up dialog. The line numbers of all subsequent lines in the set-up dialog decrease by one.

LINE # : n,1 This response inserts a new breakpoint at line n. The line numbers of the previous line n and all subsequent lines are increased by one.

Note: No new last breakpoint (i.e., the breakpoint immediately preceding the final slope) can be added due to confusion with the FINAL SLOPE query.

LINE # : n This response (the normal response to the LINE # query) allows modification of the parameters of the breakpoint at line n.

When adding or modifying a breakpoint, only a frequency-and-level breakpoint type is allowed. At the time of the CORRECTIONS task the program converts any slope-type breakpoints that were entered to frequency/level form, so that at CORRECTIONS time all breakpoints are of the frequency/level type.

3.3.5.3 Editing Lines #3 and #4. If the BANDWIDTH (line #3) or the RESOLUTION (line #4) are changed via the CORRECTION procedure, the following additional actions are taken:

- a. Any spectra currently preserved in memory buffers are set to zero.

- b. If pre-stored drive is active it is changed to inactive/disabled and the following message is displayed to alert you.

PRESTORED DRIVE (Y,N)? N

3.3.6 LIST? (Y/N):

Respond with Y to list the setup parameters currently in memory. Figure 3-5 shows the format of a setup parameter listing. The listing includes all corrections made to the parameters by you, and any adjustments to parameter values made by the program in reconciling the bandwidth, resolution, breakpoint frequency, and startup and shutdown time parameters. After the listing is produced, the program returns to the CORRECTIONS operation to allow further changes to the parameter set. The CORRECTIONS, LIST loop continues as long as a Y response is made to the LIST query.

Respond with N if you don't want to list the parameter set. Control then advances to the SAVE operation (see paragraph 3.3.7).

The LIST operation lists the complete parameter set, even if some of the parameters cannot be corrected due to earlier use of the ABORT key to terminate keyboard entry of parameters.

3.3.7 SAVE PARAMETERS? (Y/N):

Respond with N if it is not desired to save the parameter set. The program then terminates the setup function, returns to standby, and sets the control menu active to allow you to select another function.

Respond with Y to save the parameter set currently in memory on disk. The parameters are saved in a file with name filnam.RN, where "filnam" is the one to six character test ID parameter entered in paragraph 3.3.4.1

If 100, 200, or 400 lines of resolution has been selected, the system outputs the message

SAVE SPECTRA AND MENU? (Y/N):

to allow you to save a group of spectra and the current menu parameter values along with the parameter set. This capability is not allowed for 600 or 800 lines of resolution.

Respond with N to save just the parameters.

Respond with Y to save the control, drive, monitor, and auxiliary spectra currently in memory, in addition to the setup parameters. If these spectra are saved, they are loaded into the program memory areas for the respective spectrum types when the file is retrieved from disk.

The system then outputs the message:

SYSTEM DEVICE UNIT NUMBER:

Respond with the unit number of the disk on which the parameter set (and spectra) is to be saved. The disk type must be the same as the system device type. Following this response the disk write operation begins. When the operation is completed the setup function is ended. The program returns to standby with the control menu active. In performing the disk write, the following two situations can occur:

- If there is insufficient free space on the specified disk unit to contain the parameters (and spectra), the program aborts the write operation, prints the message

DISK FULL

and returns to standby. In this case make more room on the disk volume or mount another volume with sufficient room, and re-run the setup function. The parameters and spectra to be saved are still in memory. Another attempt to save them can be made by answering N to each of the ENTER PARAMETERS, CORRECTIONS, and LIST queries, and Y to the SAVE query.

- If there is already a parameter set file on the specified disk volume with the same test ID, the write operation causes deletion of this existing file and its replacement by a new file. In this case the program displays the message

REPLACE EXISTING FILE? (Y/N):

to allow you to choose whether or not to delete the existing file.

Respond Y to allow the write operation to continue and delete the existing file. Respond N to abort the write operation and preserve the existing file.

If you wish to both preserve the existing file and save the new parameter set, respond with N and rerun the setup function. Answer N to the ENTER PARAMETERS query and Y to the CORRECTIONS query. Respond to the LINE # statement with 1 and enter a new test ID parameter that does not duplicate any parameter set file on disk that is to be preserved. Then proceed with the setup function and answer Y to the SAVE PARAMETERS query.

Note: A special parameter file named RANDOM.RN can be saved on the disk. If the file exists when the program is initially loaded, these setup parameters are automatically read into memory and are active when the program starts.

3.3.8 3=SCHEDULE

The test schedule portion of the setup function is independent of the remainder of the function (which deals with setup parameters) and contains its own means of saving and recalling test schedule files. The response of 3 to the INPUT query of paragraph

3.3.2 causes the program to display the following list of test schedule setup operations:

```

0=EXIT
1=RECALL
2=SAVE
3=LIST
4=NEW
5=VERIFY
6=MODIFY
7=REPEAT
8=REMOTE
9=OFF
?
```

Respond to the ? with a number (0 through 9) to select an operation. Except for 0=EXIT and 9=OFF, the above list of operations repeats after each completed operation.

3.3.8.1 0=EXIT. Enter 0 to leave the test schedule portion of the setup function and return to standby. Test scheduling is then in effect; execution of the test function causes the schedule to be executed.

3.3.8.2 1=RECALL. Enter 1 to load an existing test schedule file from disk into memory. The system displays the messages

```

RECALL FILENAME:
UNIT NO:
```

Respond to the RECALL Message with the 1 to 6 character name of a schedule file. Respond to the UNIT message with the number of the disk unit where the file will be sought. The disk device type is assumed to be the same as that of the system device, i.e. the type on which the operating system resides. If the file is located it is loaded into memory and the operation completes normally. If the file cannot be found on the specified disk unit the message

```

FILE NOT FOUND
```

displays and the operation aborts.

3.3.8.3 2=SAVE. Enter 2 to save on disk the test schedule currently in memory. The system displays the messages

```

SAVE FILENAME:
UNIT NO:
```

Respond to the SAVE message with the 1 to 6 character name that becomes the filename of the saved schedule file (and which must be used to recall it). Respond to the UNIT message with the unit number of the disk on which the file is written. The

write operation is then performed. The schedule is saved with name filnam.RNQ. If a file of the same name is already present on the specified disk unit, the message

REPLACE EXISTING FILE? (Y/N)

displays. Respond Y to over-write the existing file, or N to preserve the existing file and abort the SAVE operation.

If there is insufficient free space on the disk to contain the file, the program displays the message

DISK FULL

and aborts the operation.

3.3.8.4 3=LIST. Enter 3 to list the test schedule currently in memory. A schedule includes a series of up to 63 sequence numbers, where each sequence number identifies a test to be run by specifying the parameter set file for the test, gives the disk unit number on which the file resides, and gives a status for the test. The following schedule below illustrates the format for a test schedule listing.

TEST SCHEDULE

REMOTE SELECTED (occurs only if remote is active)

REPEAT SELECTED x LOOPS or CYCLES (occurs only if repeat is selected)

SEQUENCE NO.	FILENAME	UNIT NO.	STATUS
1	TEST3	0	NEW
2	TEST15	1	0,2,0
3	TESTA	1	NOT RUN
:	:	:	MISSING
63	TESTX	0	VERIFIED

A test schedule listing is automatically displayed at the start of each loop or cycle when the schedule is executed, and is also included as part of the post-test message for a scheduled test. The following is an explanation of the STATUS indications in the listing:

NEW	This file name has just been entered in the schedule, either from the keyboard or by reading a disk file.
VERIFIED	This setup file was present on the disk when the VERIFY function was last performed.
MISSING	The test setup file was not present when VERIFY was performed.
h, m, s	Cumulative time at full level (or level schedule) for which the test was run during the last test schedule execution.

NOT RUN During the last execution, this test was not run, either because of previous aborts or modification of the sequence under remote control.

3.3.8.5 4=NEW. Enter 4 to erase any test schedule currently in memory and enter a new one from the keyboard. The program requests new schedule entries as shown below:

SEQUENCE NO. 1
FILENAME:
UNIT NO:

SEQUENCE NO. 2
FILENAME:
UNIT NO:

and so on.

Respond to each FILENAME message with the test ID of a setup parameters file. Respond to the associated UNIT message with the disk unit number on which the file is found when the schedule is executed.

After all desired sequence numbers have been supplied, respond to the next FILENAME message with CTRL/D to terminate the schedule entry operation.

3.3.8.6 5=VERIFY. Enter 5 to verify that all setup parameter files named in the schedule are present in the system on the indicated disk units. There is no output produced by the VERIFY operation, but following the completion of verification an automatic LIST is performed, and indicates either a VERIFIED or a MISSING status for each test.

There is no way for the program to determine whether a disk has been removed or a parameter file deleted subsequent to the VERIFY. An opportunity to perform another verify operation is provided when a scheduled test is executed.

3.3.8.7 6=MODIFY. Enter 6 to modify the test schedule currently in memory. The program outputs the following messages:

0=CHANGE
1=DELETE
2=INSERT
?

Respond to the ? with 0 to CHANGE a sequence number in the schedule. The program displays the messages

CHANGE SEQUENCE NO:
FILENAME:
UNIT:

Respond with the sequence number to be changed, and then the new filename and disk unit number.

Respond with 1 to DELETE a sequence number. The system displays the message

DELETE SEQUENCE NO:

Respond with the number of the sequence to be deleted. All subsequent sequence numbers in the schedule are renumbered.

Respond with 2 to INSERT a new sequence number. The system displays the message

INSERT SEQUENCE NO:

FILENAME:

UNIT:

Respond with the sequence number for the new entry, and then the new filename and disk unit number. All subsequent sequence numbers in the schedule are renumbered.

3.3.8.8 7=REPEAT. Enter 7 to select single or repeated execution of the tests in the schedule. The program displays the following messages:

0=OFF

1=LOOP

2=CYCLE

?

Respond to the ? with 0 to select single (non-repeat) execution of the schedule. Example: If a test schedule contains four sequence numbers, the non-repeat execution sequence is 1,2,3,4.

Respond with 1 to select LOOP execution. The program displays the message

LOOPS:

Respond with the number of loop repetitions desired. The loop execution sequence is 1,2,3,4,1,2,3,4,. . . where one loop is once through the schedule.

Respond with 2 to select CYCLE execution. The program displays the message

CYCLES:

Respond with the number of cycle repetitions desired. The cycle execution sequence is 1,2,3,4,3,2,1,2,3,4,3,. . . where one cycle is once through and once back.

3.3.8.9 8=REMOTE. Enter 8 to select local or remote operation for the test schedule when it is executed. The program displays the following messages:

```
0=OFF
1=ON
2=LIST
?
```

Respond to the ? with 0 to select local execution and to clear any remote line number assignments currently in effect.

Respond with 1 to select remote execution. If the remote interface hardware is not present in the system, the system outputs the following message and then repeats the messages at the start of this sub-paragraph.

NO REMOTE HARDWARE!

If the required hardware is present the system requests entry of the remote line numbers that will control the remote execution, via the messages below.

```
ENTER LINE NUMBERS (1-16) FOR
REMOTE STOP x
REMOTE START x
SEQUENCE NO. x,x,x,x,x,x, (up to six)
REMOTE READY x
REMOTE INCREASE x
```

Respond with line numbers as indicated by the x characters, where all but the SEQUENCE NO. message require one line number only. The SEQUENCE NO. message response may consist of one through six consecutive line numbers separated by commas. The SEQUENCE, READY, and INCREASE lines are optional. If you don't want to define these lines, respond to the appropriate message with 0.

Respond with 2 to LIST the remote setup lines. This operation is effective only if remote execution is currently selected; if local execution is in effect the LIST operation is ignored. The listing produced has the following format:

```
LINE NUMBERS (1-16) FOR
REMOTE STOP x
REMOTE START x
SEQUENCE NO. x,x,x,x,x,x
REMOTE READY x
REMOTE INCREASE x
```

3.3.8.10 9=OFF. Enter 9 to erase the test schedule currently in memory, cancel test scheduling, and return to standby. Upon return to standby test scheduling is not in effect. If the test function is selected the resulting test execution does not involve test scheduling. (Contrast 9=OFF with 0=EXIT).

If the schedule is wanted for subsequent use it must be saved before selecting 9=OFF, since this operation includes erasure of the resident schedule.

3.4 LOOP CHECK FUNCTION

To initiate the loop check function press MENU, set the function parameter to LOOP CHECK, and press EXECUTE.

The loop check function provides a continuity test of the control loop, which includes the system, the external load, and all interconnections. When the loop check function is entered, the program displays the following message in the query area of the CRT:

LOOP CHECK MAX DRIVE (VOLTS):

Respond with a value specifying the maximum drive signal rms magnitude (in volts) to be output to the external load during the loop check. The check operation then begins, with a random drive signal generated and output at a gradually increasing level and all input channels continuously monitored. A complete loop check typically requires less than 10 seconds for bandwidths of 2000 Hz or greater. The check operation can have any of the three following outcomes, following which the program returns to standby with the control menu displayed on the CRT.

- **Noisy loop:** If a response signal above 15 mV is detected on any input channel before the drive signal is output, a noisy loop condition exists. The program terminates the operation and displays the message

NOISE ON SIGNAL—CH x

where x is the number of the channel where the false response was detected.

- **Loop ok:** If the program detects a response signal of greater than 15 mV on each active control before the drive level reaches the specified loop check maximum drive value, the operation is successful. The program terminates the operation and displays the message

LOOP OK

- **Open loop:** If no 15 mV or greater response is detected on an input channel by the time the drive signal has reached its loop check maximum value, an open loop condition exists. The program terminates the operation and displays the message

OPEN CTL LOOP—CH x

where x is the channel number where no response was detected.

A loop check is also performed at the start of each test. The loop check maximum drive value used for the pre-test check is specified as a setup parameter (see paragraph 3.3.4.34) and is independent of the value entered in response to the LOOP CHECK MAX DRIVE message that occurs at the start of the loop check function.

3.5 TEST FUNCTION

To initiate the test function press MENU, set the function parameter to TEST, and press EXECUTE.

The test function performs a controlled RANDOM vibration test of an external load, using any valid setup parameter file. Control of the system during a test is via the keyboard, specifically by use of the special function keys to select and change control menu parameters, and by general use of the alphanumeric keys to enter parameter values and respond to program queries. Test progress and results may be displayed on the system CRT, and can be copied to the optional system printer or digital plotter. Before starting a test, verify the following items:

- The setup function must be executed to establish the desired setup parameters in memory. If a prestored drive is to be used, verify that the spectrum to be re-used is in memory, and that the resident parameters have been modified to allow its use. To help determine this, the reference spectrum and the alarm tolerance bands resulting from the resident parameters can be displayed by setting the following menu parameters as indicated:

Display = STANDARD
Spectrum = REFERENCE
Tolerance bands = ALARM

- The loop check function must be performed using the same loop check maximum drive voltage as that entered in the setup parameters. This verifies that the test starts without over-driving the external load.
- Test logging must be enabled or disabled as appropriate, via the test log function.

This paragraph describes only a non-scheduled test. No instructions for test scheduling are given here. For operating instructions regarding test scheduling see paragraph 3.9.

3.5.1 Typical Control Settings

The list given below shows typical settings for the menu and setup parameters. These settings may be varied depending on the requirements of a particular test.

<u>Parameter</u>	<u>Menu or Setup</u>	<u>Selection</u>
Mode	x	AUTOMATIC
Spectrum	x	REFERENCE
Display	x	STANDARD
Vertical Scale	x	6 DECADES
Max Value	x	10 (for log)
Horizontal Scale	x	LINEAR
Graph	x	LINE

<u>Parameter</u>	<u>Menu or Setup</u>	<u>Selection</u>
Auto Erase	x	ON
Tolerance Bands	x	OFF
Cross-Hatch	x	OFF
Type	x	LINEAR
Parameter	x	1
AC Coupling	x	ON

3.5.2 Test Termination

Termination of a vibration test can occur as the result either of normal test completion or of an abort condition. In addition to the various program generated abort conditions that automatically initiate test shutdown if a condition dangerous to the external load is detected, the special ABORT key can be used at any time to stop a test in progress.

Test documentation including information about the type of termination is available following termination of a test. For details see the description of the post-test message in paragraph 3.6.

3.5.3 Display Operations

Display operations are involved with obtaining spectrum displays on the CRT and hard copies of the CRT contents. These operations are controlled by several of the special function keys and menu parameters. Unless otherwise indicated, display operations provide calibrated and labeled displays of all selectable spectra.

Once during each control loop the program re-calculates and updates all spectra. It then uses the updated spectra to update the CRT contents if the display is currently selected. The loop time is increased by the time required to produce the display. This time is approximately one second, depending on the number of spectral lines, whether points or a continuous trace is selected, and on the spectrum type being displayed. Faster control loop times are therefore obtained by turning off the spectrum display when it is not necessary to observe the progress of the test on the CRT. The display is turned off by setting the display menu parameter to the OFF selection.

During a test, the program writes system messages to you in the message block area in the upper left-hand area of the CRT. Additional system queries requiring your response appear in the query block area in the upper right hand area of the CRT.

3.5.3.1 Hardcopy Generation of Displays. Permanent copies of CRT contents may be made either on the optional printer/plotter, digital plotter, or video hardcopy hardware, if present in the system.

You may set the printer/plotter to copy the alphanumeric (not graphic) display contents continuously by selecting the keyboard AUTO-PRINT and SCROL features. To copy graphic displays, press the COPY or SHIFT-COPY or CTRL-COPY key.

(COPY, SHIFT-COPY, and CTRL-COPY produce hard copies of different sizes.) For copies produced on the digital plotter or video hardcopy unit, no designation is made between alphanumeric and graphic displays.

Annotations may be added to a standby or data replay spectrum display for the purpose of placing additional descriptive information on a display that is to be hard copied (see paragraph 2.8.3).

The following remarks pertain to the generation of hardcopy displays during a test:

Output to the digital plotter is not allowed during the test function; see paragraph 3.12.

CAUTION

It is recommended that copies not be generated on the thermal printer/plotter during the test function. This is because drive update is disabled during the COPY process and the system runs open loop. Further, to abort the test while a copy is being produced on the printer/plotter the ALARM/CLEAR key on the printer/plotter must be pressed before pressing the ABORT key.

3.5.3.2 Display Selection. Use the spectrum menu parameter to select which spectrum to display on the CRT. The selectable spectra are:

- Reference
- Monitor
- Control
- Drive
- Auxiliary
- Transmissibility
- Inverse Transmissibility
- Error

All of these spectra are available for display during a test execution, and when a test terminates the last spectrum of each type that was calculated during the test remains available for display after the program has returned to standby. During the test, if a different spectrum is selected or if the display is rescaled a new graticule with annotations is generated; otherwise the once-per-loop update simply redraws the spectrum data trace, elapsed test time, and grms values. The graticule is also re-generated when you exit from the menu. For a description of the display annotation items, including those associated with the graticule, see paragraph 2.8.3.

3.5.3.3 Vertical Scaling. The minimum and maximum values for the vertical coordinate scale of the displayed spectrum are determined by the settings of the vertical scale and maximum value menu parameters.

- **Reference, Monitor, Control, and Auxiliary Spectra.** The maximum value is set directly via the Max Value parameter as follows:

<u>Max Value</u> <u>(Vertical Scale = log DECADES)</u>	<u>Max Value</u> <u>(Vertical Scale = LINEAR)</u>
10**-4	0.01
10**-3	0.05
0.01	0.1
0.1	0.5
1	1
10	5
100	10
1000	50
10**4	100
10**5	500
10**6	1000

The minimum value is always zero if Vertical Scale=LINEAR, and is N decades below the maximum value if Vertical Scale=N DECADES.

- **Drive Spectrum.** The drive spectrum is always displayed and calibrated in units of millivolts-squared per Hz (mV^2/Hz).

<u>Max Value</u> <u>(Vert Scale=DECADES)</u>	<u>Max Value</u> <u>(Vert Scale=LINEAR)</u>
0.1	0.01
1	0.05
10	0.1
100	0.5
1000	1
10**4	5
10**5	10
10**6	50
10**7	100
	500
	1000

The minimum value is the same as for the other spectra: zero if Vertical Scale = LINEAR, or N decades below the maximum value if Vertical Scale = N DECADES.

- **Error Spectrum.** If Vertical Scale = N DECADES, the vertical center of the display is always 1, with the maximum value N/2 decades above 1 and the minimum value N/2 decades below 1. (Example: if Vertical Scale = 4 DECADES, the maximum value is 2 decades up = 100, and the minimum value is 2 decades down = .01.)

If Vertical Scale = LINEAR, the maximum value is as given on either of the two foregoing lists, and the minimum value is zero.

3.5.3.4 Horizontal Scaling. The maximum value of the horizontal (frequency) coordinate scale is equal to the BANDWIDTH setup parameter (i.e., one of the values 200, 500, 1000, 2000, 3000, 4000, or 8000 Hz). The minimum horizontal scale value is 0 for linear, or the frequency increment Δf for log. The scale can be set to either LOG or LINEAR via the Horizontal Scale menu parameter.

3.5.3.5 Erase and Auto-Erase If the auto erase menu parameter is set to ON, then as the spectrum data trace is updated during each loop the trace produced during the previous loop is erased. If auto erase is set to OFF this erasure does not occur, so that each new trace over-writes the traces from previous loops. This permits observation of changes in the spectrum. Note that if cross-hatch is ON, auto erase is forced OFF.

The ERASE key on the keyboard may be used to erase the entire display at any time. This may be required after a number of loops with auto erase OFF, if the latest data trace can no longer be distinguished from previous traces.

To regenerate the graticule and display annotations following use of the ERASE key, press MENU and then EXECUTE to enter and then immediately leave the menu display. When the spectrum display is rewritten a graticule is produced.

3.5.3.6 Point/Line and Cross-Hatch. A choice of data trace texture is provided via use of the graph menu parameter. If graph is set to LINE, the trace is drawn as a series of straight-line segments connecting the individual spectral values. If graph is set to POINTS, the data trace consists of points indicating the spectral values with no connecting lines.

If the cross-hatch menu parameter is OFF, the divisions along the horizontal and vertical coordinate scales consist only of tic marks on the scales. If cross-hatch is ON, the tic marks are extended as dotted lines across the display graticule to form a grid. Note that with cross-hatch set to ON, auto erase is forced OFF.

3.5.3.7 Tolerance Bands. The alarm limit or abort limit tolerance bands specified in the setup parameters may be added to the spectrum display by setting the tolerance bands menu parameter to ALARM or ABORT, respectively (except when the spectrum displayed is the drive, transmissibility, or inverse transmissibility, for which the tolerance bands have no meaning). If tolerance bands is set OFF the tolerance bands are not displayed but are still enabled.

3.5.3.8 Display Expansion. It is possible to designate a frequency interval within the full display range of 0 to B(bandwidth) Hz and then expand the display so that the specified frequency interval covers the entire display width. This allows better visual resolution of the details of a portion of the spectrum.

Note that display expansion is not allowed unless the program is in manual mode. If the system is in automatic mode, press MENU and set the mode parameter to MANUAL. If the parameter selection cannot be changed to MANUAL, then the automatic mode only setup parameter (paragraph 3.3.4.32) is set to Y (yes). In this case, you must execute the setup function and change the setting of this parameter to N (no), and then set the mode menu parameter to MANUAL.

While the display is expanded the annotations are not affected. In particular, the grms values for the new control spectrum and the spectrum being displayed still pertain to the entire spectrum and not just to the expansion frequency interval.

The procedure to accomplish display expansion follows.

- Step 1. Press the MENU key.
- Step 2. Set the test modification parameter to CURSOR LIMIT.
- Step 3. Set the Display parameter to CURSOR.
- Step 4. Press the EXECUTE key.

When the spectrum display reappears, two cursors appear on the display. However, the load time values for the cursors are 0 and 240 Hz so the left-hand cursor may not be visible.

- Step 5. Press the MODIFY key.

The following query appears in the query block area of the CRT:

Lower Freq (Hz):

- Step 6. Respond with the lower (left-hand) frequency of the desired expansion interval. Following the response a second query is displayed:

Upper Freq (Hz):

- Step 7. Respond with the upper (right-hand) frequency of the expansion interval.

The cursors shift position on the CRT to indicate the selected lower and upper frequencies.

- Step 8. To change the interval, press the MODIFY key. The LOWER FREQ query again displays.
- Step 9. Continue from steps 6 and 7.

- Step 10. When the interval is satisfactory, press MENU, set the display parameter to EXPAND, and press EXECUTE. When the spectrum display reappears it will be expanded so that the interval fills the whole graticule.

A quicker procedure, but one that does not allow inspection of the selected interval before expansion takes place, is as follows:

- Step 1. Press MENU.
- Step 2. Set Test Modification to CURSOR LIMIT.
- Step 3. Set Display to EXPAND.
- Step 4. Press EXECUTE.
- Step 5. Press MODIFY.
- Step 6. The LOWER FREQ and UPPER FREQ queries display. Respond as in previous steps 6 and 7.
- When the response to the second message is completed, the display expansion takes place on the CRT.
- Step 7. If the expansion interval is not correct, press MODIFY and continue from step 6.

To leave display expansion and display the entire bandwidth, either (a) set the lower and upper expand frequencies to 0 and B (Hz), respectively, or (b) press MENU, set the display parameter to STANDARD or CURSOR, and press EXECUTE. The display is then non-expanded. If CURSOR was selected, the cursors are included in the display at the values to which they were last set.

3.5.3.9 Monitor/Auxiliary Averaging. The averaging parameters for the monitor and auxiliary spectrum are determined by the settings of the type and parameter menu parameters. These parameters may be used at any time to change the monitor/auxiliary averaging, without affecting the control loop.

The RESET special function key can be used at any time to discard accumulated averages for the monitor and auxiliary spectra, and start accumulating new averages according to the averaging parameter values in effect.

3.5.4 Automatic Mode Operation

The program provides two operating modes for test execution: automatic mode and manual mode. Select automatic mode by setting the mode menu parameter to AUTOMATIC. In addition, automatic mode is forced on, and the mode parameter setting is overridden, if level scheduling, test scheduling, or automatic mode only is selected in the parameter set governing the test.

In automatic mode both manual start and auto start are available, but only automatic increase is available. See paragraphs 2.6.2.1.

To perform a vibration test in automatic mode, proceed as follows:

- Step 1. Press the MENU key.
- Step 2. Set the menu parameters to the selections shown in paragraph 3.5.1. In particular, make sure that automatic mode is in effect.
- Step 3. Set the Function menu parameter to TEST.
- Step 4. Then press the EXECUTE key to start the test.
- Step 5. A loop check is performed unless the loop check maximum drive setup parameter is set to 0, in which case this step is bypassed and test execution proceeds directly to step 6.

If a loop check is performed, one of the three following messages display:

LOOP OK	If the loop check is successful
OPEN CTL LOOP — CH x	If an open loop condition is detected
NOISE ON SIGNAL — CH x	If a noisy loop condition is detected

If the loop check is successful the test proceeds to step 4. If an open loop is detected the test aborts and the system returns to standby. If a noisy loop condition is detected the program displays the query

PROCEED? (Y/N)

in the CRT query block area. Respond Y to continue the test, or respond N to abort the test and return to standby.

Note: The program does not compute a system gain estimate (see paragraph 2.6.1) if a noisy loop condition occurs. Be advised therefore that if the test is continued the initial drive signal level may not be correct, and the test may take longer to equalize.

- Step 6. If prestored drive is not specified in the setup parameters, proceed to step 7. If prestored drive is specified, the program displays the message

PRESTORED DRIVE ACTIVE

If the setup question CONFIRM AFTER START was answered N(o) the test proceeds to step 7. If the question was answered Y(es), the program displays the following additional message in the query block area of the CRT and waits for your response.

PROCEED? (Y/N)

This gives you an opportunity to confirm that the desired drive spectrum is resident in memory by observing the displayed spectrum. If the spectrum is correct, respond with Y to allow the test to continue. If

not, respond with N to abort the test and return to standby. Then load the desired spectrum or correct the setup parameters so that another drive spectrum can be obtained.

- Step 7. The program now outputs the drive signal to the external load at low level. To see that the control spectrum is equalizing to the reference spectrum, set the spectrum parameter to CONTROL and the tolerance bands parameter to ON, and observe the spectrum display.

If the auto start setup parameter is set to Y(es), the drive signal remains at low level until the specified time at low level has elapsed and then automatically starts increasing toward full level.

If auto start is set to N(o), then manual start is required.

Wait until the control spectrum has equalized to the reference spectrum and then press the up-arrow key (↑) to cause the drive level to start increasing.

- Step 8. The drive signal level can be continuously monitored. It is located on the CRT just above the center of the top line of the graticule (see paragraph 2.8.2). The value shown for the drive level is relative to full level, where full level is 0 dB.

- Step 9. If the test is unscheduled the drive level automatically increases to full level, remains there for the specified test time, and then shuts down.

If level cycles is selected, the drive level increases to full level and stays there for the specified time, next performs the specified number of cycles (using the cycle low level and rise and decay time values from the setup parameters), and then shuts down.

If level profile is selected, the test follows the specified profile following departure from low level, using the level and time values specified in the setup parameters, and then shuts down when the profile has been completed.

If level scheduling is selected, the CYCLE # (for level cycles) or LEVEL # (for level profile) currently being executed is displayed above the upper left corner of the display graticule (see paragraph 2.8.2). Observe this display annotation during the test to note the progress of level scheduling.

In automatic mode none of the test modification features are available. In particular, you cannot disable drive update when in automatic mode. When a test uses level scheduling (cycles or profile) drive update is in effect only for drive levels of 0 dB to -20 dB. See paragraphs 2.6.4 and 2.6.5.

- Step 10. Press the ABORT key to shut down a test at any time before the test time expires.

Step 11. When test shutdown completes, the program displays one of the messages

TEST COMPLETED — SEE POST-TEST

if the test completed normally, or

TEST ABORTED — SEE POST-TEST

if test execution was aborted. The program then returns to the standby state.

The final spectra calculated during the test are still in memory and can be observed, or can be saved along with the setup parameters by running the setup function.

Further test documentation may be obtained by executing the post-test function (paragraph 3.6).

3.5.5 Manual Mode Operation

Manual mode is selected by setting the mode menu parameter to MANUAL. Manual mode is allowed only for an unscheduled test. It is disabled if level scheduling, test scheduling, or automatic mode only is selected in the resident parameter set governing the test execution.

To perform a vibration test in manual mode, proceed as follows:

- Step 1. Set the menu parameters to the selections shown in paragraph 3.5.1, except that the mode parameter must be set to MANUAL.
- Step 2. Set the function menu parameter to TEST, then press EXECUTE to start the test.
- Step 3. A loop check is performed unless the loop check maximum drive setup parameter is set to 0. For details see paragraph 3.5.4, Step 5.
- Step 4. If prestored drive is specified in the setup parameters, the program displays a message and waits for your input before proceeding. For details see paragraph 3.5.4, Step 6.
- Step 5. The program now outputs the drive signal to the external load at low level.

Set the spectrum menu parameter to CONTROL and the tolerance bands parameter to ON, and observe the display to watch the control spectrum equalize to the reference spectrum.

If auto-start is in effect the drive signal remains at low level until the time at low level elapses, and then automatically increases by one level increment. If manual start is in effect (auto start = NO) the drive will stay at low level until you press the up-arrow key ($\uparrow$) to increase the level.

Step 6. During the test the drive level can be continuously observed in the center of the display above the center of the top line. The value shown is in dB relative to full level, (full level is defined as 0 dB).

Step 7. Press the $\uparrow$ key to cause the drive signal level to increase to full level. Each time after the $\uparrow$ key is pressed the drive level displayed on the CRT can be observed to increase by one level increment.

The level increment and the test low level are setup parameters. The number of increases required to achieve full level (0 dB) is determined by dividing the quantity (full level - low level) by the level increment. (Example: If low level is -20 dB and the level increment is 4 dB, then the $\uparrow$ key must be pressed $(0 - (-20))/4 = 5$ times to advance the drive signal from low to full level.)

During the test both the down-arrow ($\downarrow$) and up-arrow ($\uparrow$) keys are enabled to allow you to decrease ($\downarrow$) as well as increase ($\uparrow$) the drive signal level.

Each time one of these keys is pressed the drive level decreases or increases by one level increment (except that the drive level cannot be increased above 0 dB). Only one level change is allowed per loop. Successive keystrokes in a loop are ignored after the first $\uparrow$ or $\downarrow$ key is acted on.

In manual mode the test modification capabilities may be used while the test is in execution to disable drive update, modify the reference spectrum, change the auxiliary channel, or expand the display. Instructions for these modification operations are given in paragraph 3.5.6.

The test accumulates time that counts towards test completion only while the drive signal is at full level (0 dB). If the test level is decreased from full level by pressing the $\downarrow$ key, the test ceases to accumulate elapsed test time. The current elapsed test time is included as an annotation to the spectrum display by the lower left corner of the display graticule (see paragraph 2.8.2).

To shut down a test at any time before the test time elapses, press the ABORT key.

If no automatic or manual abort occurs, the test shuts down after it has accumulated time at full level equal to the value of the test time setup parameter.

Step 8. When test shutdown is complete the program displays either

TEST COMPLETED — SEE POST-TEST or
TEST ABORTED — SEE POST-TEST

depending on whether the test completed normally or was aborted, and then returns to standby. The final spectra computed in the test are still resident in memory and can be displayed or saved with the setup parameters. Summary information about the test is available by executing the post-test function (see paragraph 3.6).

3.5.6 Test Modification

The capability for changing certain test conditions either in standby or while the test is executing is controlled by the test modification menu parameter. Four types of modification are provided, operating instructions for each of which are given in the following sub-paragraphs.

Note: All types of test modification are enabled in manual mode only.

3.5.6.1 Modify Reference Spectrum. This feature may be used to alter the reference spectrum for the test. A modification is made by changing the level of a segment of the spectrum. Any number of such modifications can be made. If modifications are performed during a test, the control spectrum can be observed equalizing to the changed reference spectrum after each modification is made.

The modification process is used to form a more complicated reference spectrum than is possible by use of the slope breakpoint definition process that is part of the setup function. In particular, spectrum modification generates a reference spectrum of such a shape that would require more than 40 breakpoints.

A modified reference spectrum cannot be saved on disk, and so can be used only as long as it remains in memory and is not over-written by a new reference spectrum or a newly-loaded copy of the RANDOM program. A modified reference spectrum with 100, 200, or 400 lines of resolution can be preserved for later use by means of the Control to Measured PSD capability (paragraph 3.8), where the monitor spectrum that results from the process is equalized to the modified reference spectrum.

CAUTION

Too great an increase in the reference spectrum level can result in possible loss of control. Small increases, or decreases of any magnitude, do not lead to control problems. Increases of 6 dB or greater in a portion of the reference spectrum can cause control loss in that portion of the spectrum, due to digital-to-analog saturation caused by increased drive signal level and/or analog-to-digital overload caused by increased control signal level.

Individual modifications that increase the reference spectrum by more than 6 dB are rejected (see step 5). However, it is possible to modify the same portion of the reference spectrum twice so that the total level increase in the portion exceeds 6 dB. However, such modification may produce a control loss condition.

To modify the reference spectrum proceed as follows:

- Step 1. Press the MENU key, set the display menu parameter to CURSOR, and make sure the mode parameter is set to MANUAL. If it is desired to visually observe the modification, either set the spectrum parameter to REFERENCE, or set the tolerance bands parameter to ON.
- Step 2. Set the test modification menu parameter to CURSOR LIMIT and press the EXECUTE key to regenerate the spectrum display. A pair of vertical line cursors appear somewhere on the display (except that if either cursor happens to be currently positioned at the left, 0 Hz, or right, B Hz, edge of the display that cursor is not visible).
- Step 3. Press the MODIFY key. The following two queries appear in the query block area of the display, in the order shown:

Lower Freq (Hz):

Upper Freq (Hz):

Respond to each query with a number (in Hz) specifying respectively the left and right hand limits of the segment of the reference spectrum to be modified. When the response to the second message is completed the cursor lines change position on the display to correspond to the selected upper and lower frequencies.

This step can be repeated as often as required to move the cursors to a desired position.

- Step 4. Press MENU, set the test modification parameter to REFERENCE, and press EXECUTE. The spectrum display reappears.
- Step 5. Press the MODIFY key. The following query appears in the display query block area:

Change (dB or -dB):

Respond with a number (in dB) specifying the change in reference spectrum level. A positive number causes a level increase, a negative number causes a decrease. Positive values greater than 6 are rejected by the program to minimize the chance of control loss.

When the response is completed the reference spectrum modification takes effect and is displayed if the spectrum menu parameter is set to REFERENCE or the tolerance bands are displayed.

- Step 6. To modify another segment of the reference spectrum, perform steps 2 through 5 again. Do this repeatedly to modify the reference spectrum as extensively as desired.

3.4.6.2 Modify Auxiliary Channel. Analysis of data from an auxiliary channel allows the spectrum of any single input channel, whether designated as a control channel or not, to be observed during a test. Averaging for the auxiliary channel is controlled by the type and parameter menu parameters (see paragraph 3.2.3). During a test the auxiliary channel number can be reassigned to permit the spectrum of each input channel to be individually inspected.

To assign an auxiliary channel (if no assignment is present in the setup parameters) or to change the present auxiliary channel assignment, proceed as follows:

Step 1. Press the MENU key. Set the spectrum menu parameter to AUXILIARY and the test modification parameter to AUX CHANNEL. Press the EXECUTE key. The spectrum display reappears. If a test is in progress and an auxiliary channel is currently defined, the auxiliary spectrum displays.

Step 2. Press the MODIFY key. The query message

AUXILIARY CHANNEL:

displays in the query block area. Respond with the number of the input channel that is to be the new auxiliary channel.

If the selected channel number is also the number of a control channel, the reassignment is complete at this point. The queries in step 3 below do not occur in this case because the level settings of a control channel cannot be changed without affecting equalization. Proceed to step 4.

Step 3. If the selected channel is not also a control channel, the following query block messages display in the order shown:

MAX EXPECTED GRMS:

ACCEL SENS (MV/G):

Respond to the MAX GRMS query with an estimate (in g) of the highest overall grms anticipated for the new auxiliary spectrum.

Respond to the ACCEL SENS query with the input signal sensitivity (in millivolts per g). This quantity is usually indicated on the accelerometer itself.

Step 4. When the response is completed the new channel assignment takes effect. If a test is running the new auxiliary spectrum displays. An automatic RESET of the auxiliary spectrum only (not the monitor spectrum) is performed when the auxiliary channel is modified, so that a new average is started for the new channel assignment.

Step 5. Repeat steps 1 through 4 to modify the auxiliary channel.

3.5.6.3 Drive Update Disable/Enable. This modification capability is enabled only during a test execution. Normally, drive update is enabled during a test. When drive update is disabled the test continues uninterrupted, but the drive spectrum remains the same as it was before being disabled and does not change to equalize the control spectrum to the reference spectrum, even if the control spectrum itself changes.

To disable drive update, proceed as follows:

Step 1. Press the MENU key, set the Test Modification menu parameter to DRIVE UPDATE, and press the EXECUTE key. The spectrum display reappears.

Step 2. Press the MODIFY key. The message

Drive Update (1=ON, 0=OFF):

displays. Respond with 0 to disable drive update.

To re-enable drive update:

Step 3. Press MODIFY. The message

Drive Update (1=ON, 0=OFF):

again displays. Respond with 1 to reinstate drive update.

The above procedure can be performed as often as desired during a test.

3.5.6.4 Display Expansion. Display expansion is a test modification feature. A description and operating instructions for this type of modification is given in paragraph 3.5.3.8 as one of the display operations.

3.5.7 Data Storage During Test

For data storage to occur during a test, the storage capability must be enabled in the setup parameters governing the test (paragraph 3.3.4.33). The setup parameters also specify the unit number of the disk on which the data is to be stored, and whether storage is to occur automatically at a specified interval (AUTO-STORE) or by your action (MANUAL). Storage may not occur more often than once per loop.

Storage of data is into a disk file on the specified unit number. This file has the name testid.Rnn, where testid is the one-to-six character test identification and nn is a program assigned run number (01 to 99). The test ID appears in the bottom line of annotations to the spectrum display, below the left corner of the graticule (see paragraph 2.8.2). Each time storage occurs one record is stored in the file. A record contains a number of spectra and other test parameters, as described in paragraph 2.9.4.

Data storage is not allowed for 600 or 800 lines of resolution.

The periods during a test for which data storage is enabled depend on the type of level control in effect for the test as follows:

- **Unscheduled level control.** Storage is not enabled until the test has reached full level. If MANUAL STORE is selected storage is enabled for the entire remainder of the test. If AUTO-STORE is selected storage is enabled as long as the test remains at full level, but is disabled if the test level is decreased below full level (note that level decrease is possible only in manual mode).
- **Level profile.** Storage is not enabled until the test leaves low level, but is enabled at all times thereafter.
- **Level cycles.** A test for which level cycles is selected begins with a completed unscheduled test, after which the cycles occur. Data storage for the unscheduled test is as described above. Storage is enabled at all times during the cycles portion of the test.

The following two options to control the frequency of data storage are provided:

- **AUTO-STORE.** Your action is not required to store data records. Storage automatically occurs at specified intervals, and in addition the final spectra are stored when the test shuts down due to normal completion or an abort.
- **MANUAL STORE.** Press the right-arrow (→) key each time it is desired to store a data record, but not more often than once per loop. The final spectra are not automatically stored at the end of a test, but are still available in memory and are separately stored, if desired, as part of a setup file.

If disk hardware problems occur when data storage is attempted the program displays the message:

DISK I/O ERROR

If there is insufficient free space on the disk for further storage the program displays the message:

DISK FULL

These conditions do not shut down the test but caution that data is not being stored.

Note: It is important to determine that there is enough contiguous free space on the disk before attempting storage, because the program does not check for this condition in advance.

3.6 POST-TEST FUNCTION

To initiate the post-test function press MENU, set the function parameter to POST-TEST, and press EXECUTE.

3.6.1 Post-Test Message

The post-test function displays a message that summarizes and documents the most recent test or analysis function execution. The post-test display has the form shown below. The parenthesized quantities indicate referenced paragraph numbers.

TESTID	Test ID setup parameter (3.3.4.1).
TEST HEADING	Test heading setup parameter (3.3.4.1).
COMMENTS	Comments setup parameter (3.3.4.1).
BANDWIDTH: nnn	Bandwidth setup parameter (3.3.4.2).
RESOLUTION: nnn	Resolution setup parameter (3.3.4.3).
REFERENCE GRMS: n.nn	Reference spectrum GRMS (3.3.4.11).
CONTROL CHANNELS: n,...,n	Control channels selected (3.3.4.26).
AUXILIARY CHANNEL: n	Auxiliary channel selected (3.3.4.28).
(REMOTE) SEQUENCE: n	Optional item, occurring only if test scheduling (3.3.2, 3.3.8) is selected. The quantity n is the test schedule sequence number for this test. If the remote operation option (3.3.8.9) is selected, the REMOTE notation is added to this item.
TIME:	RT-11 time of day when post-test message generated.
DATE:	RT-11 date when post-test message generated.
TEST CODE: a...a	Optional item, occurring only if test logging (3.11) is enabled. If test logging is enabled and a test code is defined, the code a...a is included; if no test code is defined the TEST CODE notation still occurs but no code is included.
RUN NUMBER: nn	Optional item, occurring only if spectra storage (2.9.4, 3.3.4.33) is selected. The quantity nn is the run number that identifies the data file testid.Rnn (2.9.7, 2.9.9) in which the spectra for this test were stored.
COMPLETED or ABORTED	Indicates whether test ended normally (completed) or was aborted (aborted).

Reason for Abort Appears only if test is aborted, see paragraph 3.6.2 below.

LOW LEVEL (-DB): -nn Test low level in dB below full level (3.3.4.15).

TIME (HRS,MIN,SEC): n,n,n Actual time spent at test low level.

One of the following messages occurs next, depending on whether the test is unscheduled or whether level scheduling (cycles or profile) is selected:

TEST TIME (HRS,MIN,SEC): n,n,n Occurs if test is unscheduled or if level cycles selected. Gives the actual time at test full level (unscheduled test) or actual time above test low level (level cycles).

LEVEL #	LEVEL (DB)	TIME (H,M,S)	Occurs if level profiles selected. Gives actual times spent at each defined level of the profile and the number of loops completed.n If the test is aborted then this number is the completed loops - 1..
1	nn	n,n,n	
2	nn	n,n,n	
3	nn	n,n,n	
etc.			

LOOPS COMPLETED: n

REMAINING TIME (HRS,MIN,SEC):n,n,n Computed as the test time setup parameter (3.3.4.20) minus either the TEST TIME value (from above for an unscheduled or level cycles test), or the sum of all the level times (from above for a level profile test).

MAX ERROR n.n DB AT nnn Hz This is the maximum value of any line in the error spectrum at the end (normal completion or test abort) of the test.

ALARM	OCCURRENCES	Occurs only if alarm(s) occurred in any loop during test execution. See paragraph 3.6.3 below for a list of the possible reasons for alarm. The quantities "n" indicate the number of loops in which the alarm of each type occurred. Only those reasons for alarm that actually occurred during the test display.
Reason for Alarm	n	
Reason for Alarm	n	
etc.		

REPEAT POST-TEST MESSAGE? (Y/N): Repeat message or exit, see below.

Respond to the final REPEAT line of the post-test message with Y to erase the CRT and repeat the message. Respond with N to exit from the post-test function and return to standby with the menu active.

3.6.2 Reason for Abort

The following is a list of possible Reason for Abort lines that can occur in the post-test message.

OPERATOR HALT!	Manual ABORT.
GRMS EXCEEDED!	The grms level of the updated control spectrum $ C_E _N^2$ exceeded the abort level setup parameter (paragraph 3.3.4.14).
CTL SIGNAL LOSS!	The grms value of $ C_E _N^2$ dropped more than 3 dB from the grms for the previous spectrum $ C_E _{N-1}^2$ and is also more than 3 dB lower than the reference spectrum grms.
CTL SIGNAL LOSS! CH x	The grms value of the unaveraged spectrum for channel x dropped below 1/8 the level of the previous grms for the spectrum.
GSQR/Hz LIMITS EXCEEDED! FREQ (HZ) ERR (DB)	One or more lines in $ C_E _N^2$ exceeded the abort limit tolerance bands. These messages are followed by a list of the frequencies and levels of out-of-tolerance frequency lines.
POWER FAIL!	Test was interrupted by system power failure.
ABORT LINE ON! ABORT LINE x	Signal was received on your external abort line number x.
OPEN CTL LOOP — CH x	Open or noisy loop condition detected on channel x during loop check.

3.6.3 Reason for Alarm

The following is a list of possible reason for alarm lines that can occur in the post-test message.

INPUT OVERLOAD	One or more sampled values on a control channel or the auxiliary channel have exceeded the full-scale (peak voltage) input sensitivity (3.3.4.29).
G2/HZ LINES	One or more lines of the control spectrum have exceeded the alarm limits (3.3.4.7).
ALARM GRMS	The overall GRMS value of the control spectrum exceeded the GRMS alarm limit value (3.3.4.14).

EXTERNAL LINES	An alarm condition occurred on one or more of the external alarm lines (3.3.4.36).
DRIVE OVERLOAD	Lines in the drive spectrum reached full-scale in an attempt to equalize to the reference spectrum (2.10.1).

3.6.4 Documentation for Test Scheduling

Following a test scheduling run, with either local or remote control, the post-test function outputs a listing of the test schedule (see paragraph 3.3.8.4), and then generates the usual post-test message for the last test in the schedule that was executed.

The STATUS column of the test schedule listing indicates for each test either the time that the test was run, or indicates NOT RUN for all tests following the last one executed if the schedule was aborted for any reason.

3.6.5 Test Logging and the Post-Test Message

If the test logging function is enabled, then at the conclusion of each test (either a normal test completion or a test abort) the post-test message is automatically written into the active test log file. See paragraph 3.11 for a description of the test log function.

3.7 ANALYSIS FUNCTION

To initiate the analysis function:

- Step 1. Press MENU.
- Step 2. Set the function parameter to ANALYSIS and the spectrum parameter to MONITOR or AUXILIARY.
- Step 3. Press EXECUTE.

The program then displays the following message in the query block area of the CRT:

MAXIMUM EXPECTED GRMS:

- Step 4. Respond with a number (in g) representing the largest overall spectrum level expected from the signal or any one control channel.

When the response is completed, data acquisition and analysis starts. Input and analysis of data continues until the test time specified in the setup parameter has elapsed, at which time the function terminates and the program returns to standby.

You may manually terminate the function at any time by pressing the ABORT key.

The analysis function does not perform closed-loop control as does the test function. No drive signal is output in the analysis function. Instead, data is acquired from each channel specified in the setup parameters as a control or auxiliary channel. During each control loop of the program, an auxiliary spectrum is computed for the auxiliary channel (if defined), and a single composite spectrum (monitor spectrum) is computed for all control channels. Auxiliary spectra and monitor spectra for successive loops are averaged together according to the monitor/auxiliary averaging parameters in effect in the control menu (see the description of Type and Parameter in paragraph 3.2.3), and are updated as usual once per loop. The channel specified as the auxiliary channel may also be one of the control channels.

Use of the analysis function thus allows spectra for the data from any single input channel (the auxiliary spectrum) or from any group of input channels (the monitor spectrum) to be computed and examined. The data typically consists of either pre-recorded signals on analog tape or responses from accelerometers mounted on the external load. The load may be excited by impulse or by shaker excitation or the load may be a machine, structure, or vehicle in actual use, with the excitation provided by the operation or use environment of the load.

Not all menu parameters are relevant to the analysis function. The mode parameter is not used. The only available selections for the spectrum parameter are MONITOR, AUXILIARY, TRANSMIS, and 1/TRANSMIS. All display related parameters are active except tolerance bands. The monitor/auxiliary averaging parameters are of course pertinent. Of the test modification features, only the AUX CHANNEL reassignment and CURSOR LIMIT for display expansion are active. Similarly, since no drive signal or reference spectrum is involved in the analysis function, many of the setup parameters are ignored.

The following is a list of those setup parameters that are required for the analysis function:

- Test ID
- Comments
- Heading
- Bandwidth
- Resolution
- Test time
- Control channel definitions
- Auxiliary channel definition
- Accelerometer sensitivities
- Spectrum storage
- AC coupling

Exercise spectrum storage at any time during execution of the analysis function, either in AUTO-STORE or MANUAL mode. Reassign the auxiliary channel as desired, the display can be expanded, and the monitor/auxiliary averaging parameters can be changed. Use the RESET key to discard the existing monitor and auxiliary spectra and start accumulating new spectra.

Following completion of the function the post-test message is available, and stored spectra are retrieved via the data replay function.

3.8 CONTROL TO MEASURED PSD

The Control to Measured PSD capability is exercised as a sequence of steps involving several program functions. It allows you to generate a reference spectrum from real, experimental data without the constraint of the slope-breakpoint definition process. You may then run a test that equalizes (controls) to this spectrum. The procedure given below is recommended.

Note that the following procedure requires that spectra be saved on disk along with setup parameters. Since disk storage is not available with resolutions of 600 and 800 lines, it follows that Control to Measured PSD is not available for these resolutions.

- Step 1. Execute the analysis function or the test function to compute an averaged monitor spectrum from the input for some experimental test. If required, make adjustments to the experiment and run the analysis or test function repeatedly, until the monitor spectrum is suitable for later use as a reference spectrum. At the end of this procedure the desired monitor spectrum and its resolution and bandwidth parameters reside in the system memory.
- Step 2. Immediately following step 1 execute the setup function and save the setup parameters and spectra on disk. This preserves the monitor spectrum in case the system is turned off or the monitor spectrum is inadvertently over-written.
- Step 3. When you wish to use the stored monitor spectrum as a reference spectrum, execute the setup function again and load from disk the setup parameter file that was saved in step 2. The program notes the presence of spectra accompanying the setup parameters and displays the statement

MOVE MONITOR PSD TO REFERENCE? (Y/N):

Respond with Y. The program transfers the monitor spectrum into the reference spectrum storage area. The normal setup dialog then occurs for entry of setup parameters except that the following parameters, which are tied to the measured reference spectrum, need not be entered: resolution, bandwidth, initial slope, breakpoint levels, and final slope. (See also paragraph 3.3.3, c.)

Up to forty breakpoint frequencies may however be defined, but only for the purpose of entering alarm and abort limits for the measured reference spectrum. The program automatically examines the measured spectrum and calculates from it values for the initial and final slopes, the level at each defined breakpoint frequency, and the overall spectrum grms level. These calculated values appear during the setup dialog and when the parameters are listed.

- Step 4. If the parameter set and spectra resulting from step 3 are saved on disk as a setup parameter file, and if that file is recalled from disk in a later execution of the setup function, and if the MOVE MONITOR PSD TO REFERENCE statement is answered N(o), the program displays the message

MEASURED PSD STILL ACTIVE

This indicates that the (measured) reference spectrum is being used in the form loaded from disk, and is not being recomputed from the breakpoint parameter values as is usually the case. The breakpoints in a parameter set with a measured reference spectrum are used only to establish alarm and abort levels for the spectrum. The program flags and detects this situation by setting the initial and final slope values to zero when a measured reference spectrum is saved. This is why both slopes should not be given zero values during setup. See paragraph 3.3.4.6.

- Step 5. Now execute the test function. The program controls the external load to the measured spectrum determined in step 1.
- Step 6. If the test is satisfactory, the setup parameters and spectra may be saved for re-use in a subsequent test.
- Step 7. If a monitor spectrum is collected in the test, it may be converted to a measured reference spectrum for yet another test. Successive iterations of this kind are used to refine a measured reference spectrum for a particular testing requirement.

3.9 TEST SCHEDULING AND REMOTE CONTROL

Test scheduling allows you to specify up to 63 individual vibration tests, each defined by its own setup parameters file, and to run these tests automatically in a specified sequence. For other information regarding the test schedule capability see paragraphs 2.7 and 3.3.8.

Test scheduling is performed under local or remote control. When remote control is used, test execution is externally controlled from a remote device such as an environmental test chamber or another computer. Remote control signals are accepted through the optional 16-line Remote Communications Interface. The remote control setup procedure, described in paragraph 3.3.8.9, assigns certain of these lines to the remote control functions.

To execute a test schedule proceed as follows. The execution procedures for a test schedule in local and remote control are similar, differing in steps 5 and 12 as described below.

- Step 1. Press MENU, set the Function parameter to SETUP, and press EXECUTE.
- Step 2. Respond to the initial setup dialog as shown below (response is in bold print).

ENTER PARAMETERS? (Y/N): **Y**
 INPUT 1=KYBD, 2=DISK, 3=SCHEDULE: **3**

Step 3. The following list of test schedule operations display:

```

0=EXIT
1=RECALL
2=SAVE
3=LIST
4=NEW
5=VERIFY
6=MODIFY
7=REPEAT
8=REMOTE
9=OFF
?
```

Step 4. Respond with 1 to recall a test schedule file from disk, or with 4 to enter a new schedule from the keyboard (see paragraph 3.3.8.2 or 3.3.8.5). Following either of these operations, the list in step 3 repeats. A recalled schedule may then be modified if required by responding with 6 (see 3.3.8.7), after which the step 3 list recurs.

Step 5. Respond with 8. The following list displays:

```

0=OFF
1=ON
2=LIST
?
```

To select local control respond with 0. (This response also erases the remote line assignments.)

To select remote control respond with 1. (The system then requests selection of the remote line numbers. See paragraph 3.3.8.9.)

This step may be omitted if the test schedule already specifies the desired type of control (local or remote).

Following either of the above responses the list of test schedule operations repeats.

Step 6. If you wish to REPEAT execution of the tests in the schedule, respond with 7 to select the repeat option (see paragraph 3.3.8.8).

Note that REPEAT execution is selectable for remote control, but is exercised only if no SEQUENCE lines are selected, or SEQUENCE lines are defined but the sequence number read from these lines is 0. Otherwise, if the contents of the SEQUENCE lines are used to select the next test, the REPEAT feature is ignored.

After the response is made the list of operations in step 3 repeats.

Step 7. Mount the disk or disks containing all setup files referenced by the test schedule. Then respond to the operations list with 5 if desired to verify that all required files are present. Following the operation the list of test schedule operations repeats.

- Step 8. Respond with 0 to exit from the .setup function to standby. The test schedule is now enabled. The type of control specified in step 5 (local or remote) is in effect.
- Step 9. To execute the schedule press MENU, set the function parameter to TEST, and press EXECUTE.
- Step 10. Before test execution starts, a listing of the test schedule displays. If remote control is selected, the test schedule listing includes the following line:

REMOTE SELECTED

- Step 11. Following the schedule listing, the table of operations shown below displays:

0=EXIT
1=START
2=RESUME
3=VERIFY
?

Respond with 0 to cancel the execution and return to standby. Start again at step 1 or step 9.

Respond with 1 to start schedule execution with the test indicated by the first sequence number in the schedule (i.e., non-RESUME mode).

Respond with 2 to request test execution in RESUME mode, i.e., to start schedule execution with the test indicated by some specified sequence number. The program displays the message

RESUME SEQUENCE NO:

Respond with the desired start sequence number. Execution then starts with the selected test.

Respond with 3 to perform a final verification and listing of the test schedule. The table of operations of step 10 again displays. Return to the start of step 11 to select another operation.

- Step 12. When a START or RESUME response is made, execution of the first specified test begins. The START command clears all accumulated times (h,m,s) in the STATUS column of the listing for the test schedule (see paragraph 3.3.8.4) and sets the status to NOT RUN. The RESUME command leaves these time values unchanged, so that accumulation of new and previous run times occurs.

The sequence number (x) of the test being executed displays on the left margin of the display just above the upper left corner of the display graticule, as an annotation of the following form:

SEQ x if local control is in effect, or
REM SEQ X if remote control is in effect.

In local control, each test proceeds without need for your input, except that if the parameter set for a test specifies manual start, you must press the $\uparrow$ key to cause that test to leave low level.

In remote control, starting and stopping each test is under the control of the remote START, READY, INCREASE, and STOP lines. (See also paragraph 2.11.1, and refer to Figure 2-11 for details regarding program interrogation of the remote lines when starting each test.) Your action is not required during test schedule execution unless the REMOTE INCREASE line is not defined. In this case, if a test has manual start selected, you must press $\uparrow$ to allow the test to leave low level and proceed.

Selection of the first or next test to be run is performed in one of the following two ways:

- The tests are scheduled sequentially if
 - Local control is selected.
 - Remote control is selected but no SEQUENCE lines are defined.
 - Remote control is selected and SEQUENCE lines are defined but contain a value of zero when read.
- If remote control is selected and SEQUENCE lines are defined and when read contain a non-zero sequence number, the test selected is the one in the schedule corresponding to that sequence number. In this case the possibility of a sequence number error exists. If the number read from the SEQUENCE lines (x) is larger than the highest sequence number in the test schedule, the program displays the message

NO FILE FOR SEQ NO x

aborts the test schedule, and returns to standby.

Step 13. Upon completion of each test in the schedule, the program displays the message

TEST COMPLETED — NEXT TEST SCHEDULED

in the message block area of the display. The next setup file is read and the next test is started. This process continues, repeating loops or cycles if specified, until the schedule completes or until an abort condition or ABORT command occurs. Upon normal completion of the schedule the program displays the following messages in the order shown, in the message block area, and returns to standby.

TEST SCHEDULE COMPLETE and
TEST COMPLETED — SEE POST-TEST

The following error message and condition that is specific to test scheduling can occur to abort the schedule:

FILE NOT FOUND	Setup file named in the schedule cannot be located on disk.
----------------	---

Following an aborted schedule the message

TEST ABORTED — SEE POST-TEST

displays. The post-test function may be executed to obtain summary information about the test schedule execution. The post-test message includes a listing of the test schedule and the usual post-test message for the last test executed from the schedule (see paragraph 3.6.3).

3.10 DATA REPLAY FUNCTION

This function allows post-test retrieval and display of the data stored in a spectrum file during execution of the test or analysis function.

To initiate the data replay function press MENU, set the function parameter to DATA REPLAY, and press EXECUTE. Proceed as described below.

Step 1. The program displays the message

TEST ID:

Respond with the one to six character test identification of the setup and spectrum files to be recalled and replayed. The following message then occurs:

SYSTEM DEVICE UNIT NUMBER:

Respond with the unit number of the disk on which resides the setup file that was in effect when the spectrum data file was stored. The disk type must be the same as that of the system device.

Step 2. The above responses identify the setup file that governs the spectrum file to be replayed. The setup file is named testid.RN and is sought on device SYn:, where testid is the specified TEST ID and n is the DEVICE UNIT NO. If the setup file cannot be located the program displays the message

FILE NOT FOUND

aborts the function, and returns to standby. If the setup file is found, it is read and its contents replace the setup parameter values previously in memory.

The program then inspects the resolution parameter in the just retrieved parameter set to determine if the resolution is less than 600 lines. If so, the program proceeds to step 3 below. If not, the program aborts to standby and outputs the message

NO DATA REPLAY FOR 600/800 LINES

Step 3. The program next displays the message

RUN NO:

Respond with the run number (1 to 99) of the spectrum file to be retrieved.

This response identifies the spectrum file to be replayed. The file has the name testid.Rmm, where mm is the RUN NO. The spectrum file is assumed by the program to be located on system disk unit number specified by the device unit number setup parameter now in memory. If the spectrum file cannot be located on this disk the program, as above, displays the message

FILE NOT FOUND

aborts the file search operation and repeats step 3 starting with the RUN NO. message.

Step 4. If the spectrum file is located, the program messages continue with:

TIME HRS, MIN, SEC:

Respond with a time in the form hours, minutes, and seconds separated by commas. This quantity determines the first recalled data record. Each record when stored includes a test time value. The initial record recalled is the first record in the file with a time value equal to or greater than the time specified in this step.

Step 5. After the time response has been entered the program sequentially reads the data records in the file to locate the first record with a time value that equals or exceeds the time specified in step 4. This record then displays and the recall process pauses to allow inspection of the data in the record.

MENU may be pressed at this time and the menu parameters may be used to change the spectrum type, rescale or expand the display, etc. Pressing EXECUTE then restores the data replay display including all changes specified by user alteration of the menu parameters.

Annotations can be added to the display at this time using the CTRL/L and arrow keys. See paragraph 3.2.2 for details.

The run number (mm) of the spectrum file appears as the annotation

RUN mm

on the bottom line of the display below the left corner of the display graticule (see paragraph 2.8.2).

A cursor with frequency and amplitude readout values is provided on the spectrum display. This feature is included only on the data replay displays, and is not present on the displays that occur during standby or the test and analysis functions. The cursor is described in step 9.

If no record with a test time equal to or greater than the specified time is found, the program displays the message

END-OF-DATA

Either return to standby, or initiate a new recall sequence (see step 6).

Step 6. At this point you can exercise control over the data recall process via use of the up-arrow (↑), down-arrow (↓), and MARK keys. Two modes of recall are available: single record recall and continuous recall. When the data replay function is initiated single record mode is in effect. The ↓ key acts as a toggle switch between single record and continuous recall. In single record mode the ↑ key is used to advance to the next record. In either mode the MARK key is used to start a new recall sequence. Proceed as described below:

- **Single record recall.** Press the ↑ key to advance to the next data record in the file. When the next record is read and displayed the program pauses to allow inspection of the spectra. Repeated use of the ↑ key sequentially recalls all records in the file.

To switch to continuous recall press the ↓ key.

To start a new recall sequence press the MARK key.

- **Continuous record recall.** In continuous mode the data records are recalled and displayed one after another. When display of one record is accomplished the program automatically retrieves the next record. Each display remains on the CRT for several seconds before it is replaced by the display for the next record.

This mode allows convenient inspection of a series of data records but does not pause to allow selection of another spectrum type or to change display characteristics.

To stop the continuous recall process and revert to single record mode press the ↓ key.

To start a new recall sequence press the MARK key.

- The recall process proceeds in a forward direction only. To recall a record that has already been passed, select a new recall sequence and specify a time that is equal to or less than the time value of the desired record.
- **Initiate new recall sequence.** When you press the MARK key, the recall sequence currently in effect terminates. The recall mode is reset to single record recall. The following message list displays on the CRT:

```
1=TEST ID
2=RUN NO.
3=START TIME
?
```

Respond with 3 to retrieve data from the same file but with a new start time. Proceed from step 4.

Respond with 2 to retrieve data from another spectrum file with the same test ID but with a different run number. Proceed from step 3.

Respond with 1 to retrieve data from another spectrum file with a different test ID. Proceed from step 1.

- Step 7. If a recall sequence reaches the end of a spectrum file, either in single record or continuous mode, the program displays the message

END-OF-DATA

at this point, press the MARK key to initiate a new recall sequence.

- Step 8. The ABORT key may be pressed at any time to force the program to exit from data replay. Control returns to standby with the control menu active.

- Step 9. The cursor that is present on the data replay displays consists of a vertical dotted line that begins at the bottom edge of the display graticule and extends upward to (and terminates at) the spectrum data trace. The cursor readout appears inside the upper left-hand corner of the graticule, and consists of a frequency value (top line) and a spectrum level (bottom line). The frequency value is in Hz; units for the level are given to the left of the display graticule.

The right-arrow (→) and left-arrow (←) keys move the cursor to the right and left, respectively. The readout values change dynamically as the cursor moves. Motion of the cursor is wrap-around. If the cursor moves off one edge of the display, it reappears at the opposite edge. The cursor is initially positioned at a frequency of one-half the bandwidth (in the middle of the unexpanded display). When the cursor position is changed, the change remains in effect when the replay is advanced to subsequent records, either in single or continuous recall mode. Only when a new call sequence is initiated is the cursor returned to its initial location.

3.11 TEST LOG FUNCTION

The test log function enables or disables the capability of the RANDOM program to write the post-test message to a disk file at the conclusion of each test.

When the program is loaded into memory, the initial default condition is test logging disabled. In this case a post-test message displays as usual when the test function is executed, but the message is not written to disk and is over-written by the post-test message resulting from the next test. In order to store post-test messages on disk for later retrieval and use, the test log function must be executed and the logging capability must be enabled.

To initiate the test log function press **MENU**, set the function parameter to **TEST LOG**, and press **EXECUTE**. Proceed as described below in steps 1 through 10.

Note: The **ABORT** key is used at any time during execution of the test log function to terminate the function and return control to standby. If this is done the status of test logging is set to disabled.

Step 1. **Enable/disable test logging**

The program displays the message

```
TEST LOG ACTIVITY
ENABLE TEST LOG? (Y/N):
```

Respond with **N(o)** to disable test logging. In this case the message

```
TEST LOG DISABLED
```

displays. The function terminates and control returns to standby with the control menu active.

Respond with **Y(es)** to enable test logging. The program next attempts to locate and set active a test log file. Control proceeds to step 2.

Step 2. **Search for existing test log files**

The program searches the current system device for all files with filenames of the form

```
testid.RLn
```

where **testid** is the test ID in the current setup parameters. If any files of this kind are found their names are printed to inform you in a format such as the following:

```
.RL0 10 RECORDS 10 FILLED
.RL1 15 RECORDS 15 FILLED
.RL3 20 RECORDS 5 FILLED
etc.
```

This example shows that three test log files exist on the system device. The quantity "**m**" in the notation "**m RECORDS**" for each file indicates the maximum number of post-test messages that can be stored in the file. The quantity "**n**" in the notation "**n FILLED**" indicates the number of messages already stored in the file. Gaps in the sequence of file extensions **.RLx** (e.g., **.RL2** missing) are allowed.

If no errors were encountered in the file search, process control goes to step 5. Otherwise control continues at step 3 or 4 depending on the nature of the error.

Step 3. Non-fatal search errors

If there is a problem accessing any of the contents of the test log files located the following message displays:

.RLx DISK READ ERROR (FILE UNAVAILABLE)

If there is a discrepancy between the testid in the disk directory and the testid in the file contents, the following message displays:

.RLx ID ERROR (FILE UNAVAILABLE)

In case of either of these errors the test log function continues at step 5 but the file involved is not available to become the active test log file.

Step 4. Fatal search errors

If a directory interrogation error occurs in the file search operation for any of the ten possible existing test log files the message

DISK LOOK-UP ERROR FOR FILE testid.RLx on UNIT y

displays, and the search operation aborts. If this condition persists a disk volume or hardware error may exist.

If the file testid.RL9 exists and is completely filled with post-test messages, the message

TOO MANY TEST LOG FILES (10 ALLOWED)

displays. This condition occurs even if there are gaps in the existing test log file sequence (see step 2) or if there are existing unfilled files with x less than 9.

These conditions are considered to be non-recoverable. The message

TEST LOG DISABLED

displays and the test log function terminates. Control returns to standby with the control menu active.

Step 5. Selection of existing test log file as active file

If there are one or more existing test log files "testid.RLx" on the system device and if the file with largest x is not filled, then this file is selected as the active file. Control goes to step 9. The selected file is in all cases the existing file with largest x, even if there are unfilled files with smaller x that have more available space.

If there are no existing test log files on the system device, or if the existing file with largest x is already filled with post-test messages, then continue at step 6. Even if there is an unfilled existing file, it is not selected if it is not the file with largest x.

Step 6. Creation of new test log file as active file

If this step is reached, the program attempts to create a new test log file "testid.RLx" with a value of x that is one greater than that of the existing file with the largest x. At this point in the procedure there is at least one x of 9 or less for which a file does not yet exist and so may be created. The following messages display:

CREATING FILE testid.RLx on UNIT y
FILE SIZE? (RECORDS):

At this point verify that the correct testid and unit number have been selected. Terminate the function via the ABORT key if they are not satisfactory.

Respond to the second message with the expected number of post-test records to be stored in the new file. Each post-test message, or record is stored in a separate 256-word block of the file. (See paragraph 2.9.9.)

If the file creation operation is successful, control goes to step 9. If however, an error condition occurred control continues at step 7 or 8 depending on the nature of the error.

Step 7. Non-Fatal creation error

If your response to the FILE SIZE query in step (6) requires a file containing a greater number of blocks than the largest number of unused contiguous space on the system device, the message

ONLY ENOUGH DISK SPACE FOR FILE WITH xxx RECORDS

displays. The file is created with the reduced number of records (xxx) indicated in the message. Control continues at step 9.

Step 8. Fatal creation error

If any kind of disk access or status error occurs, the message

FAILED TO CREATE FILE testid.RLx on UNIT y

displays. In this case the test log function is aborted, the additional message

TEST LOG DISABLED

displays, and program control returns to standby with the control menu active.

Step 9. Specification of active file

The active file is selected either as the unfilled existing file testid.RLx with largest x (see step 5) or as a newly created file (step 6). The messages

```
TEST LOG ENABLED
ACTIVE LOG FILE IS testid.RLx on UNIT y
```

displays to indicate the active file. Control continues at step 10.

Step 10. Test code selection

The test code is an 8-character identifier that is included in each post-test message only if test logging is enabled (see paragraph 3.6.1). Test codes are provided to distinguish different tests with the same test ID from each other and to aid in searching a test log file for specific tests or groups of tests.

You may specify that the test code be different for each test or be the same for a number of tests, by the response to the query

PROMPT FOR TEST CODE BEFORE EACH TEST? (Y/N):

Respond Y(es) to allow selection of the test code for each test. This response causes a prompt message for the test code to occur at the start of each test (see the TEST LOG ENABLED message in paragraph 2.10.1). Control returns from the test log function to standby with the menu active and test logging enabled.

A N(o) response causes the following query to display:

TEST CODE FOR EVERY TEST:

Respond to this query with a code of 1 to 8 characters. Control then returns to standby with test logging enabled. This character string is the test code for all tests until the test log function is again executed.

3.12 OUTPUT TO DIGITAL PLOTTER

The digital plotter is an option not included in the basic system. If the plotter interface is not present in the system, the program deletes the selections from the display menu parameter so that selection of plotter output is not possible.

When plotter output is requested the current contents of the CRT are copied onto the plotter. Output to the plotter is allowed only in the data replay function with single record recall or in standby state. Plotter output is not allowed when the program is in the test or analysis function.

Selection of the Tektronix 4662 plotter (TEK) and for plotters which support the HPGL protocol are available.

To initiate plotter output proceed as follows:

- Step 1. Generate the desired display.
- Step 2. Press the MENU key, set the display menu parameter to either PLOTTER-TEK or PLOTTER-HPGL, and press the EXECUTE key.
- Step 3. The CRT contents are then copied onto the plotter. Control then returns to the function currently in effect (data replay or standby). Do not perform any further program operations until the plotter output is complete.
- Step 4. The program automatically resets the display parameter to STANDARD. It is necessary to repeat step 2 each time plotter output is desired.

Note: If the plotter is present but is turned off or is disconnected from the interface, the program halts waiting for a response from the hardware. Before outputting to the plotter, verify that all hardware connections are in place.

SECTION IV

RECEIVING CHECKOUT TEST

4.1 PURPOSE

The Receiving Checkout Test (RCT) procedures demonstrate the performance of the RANDOM vibration control program, using the test setup parameters that are contained in the program when it is loaded. The RCT also serves as a familiarization exercise for new program users.

The RCT procedures verify the following program functions:

- Operation of the pre-test loop check function.
- Detection of control system loss and noisy loop conditions.
- Generation of drive signal at low level and full level.
- Conformance of the control and monitor spectra to a preselected reference spectrum, demonstrating closed-loop equalization.
- Automatic increase of drive signal from low to full level, drive signal dwell at full level, and drive signal decrease during shutdown, all at preselected times.
- Spectrum display with calibrated graticule.
- Program operation at maximum control bandwidth.
- Multi-channel operation for two or more channels, including use of the optional 16-channel selector hardware.
- Operation of optional alarm and abort lines, and remote status lines.

4.2 CONDITIONS

This RCT procedure accommodates the standard GenRad 2500-series and 2511 Vibration Control Systems. To insure proper test results, these test procedures require that the system be installed by qualified GenRad service personnel and operated in an environment that conforms to the system specifications.

4.2.1 Software Required

The standard Random Vibration Control program, RANDOM, is furnished on diskette with part number 2511-0620.

4.2.2 Test Equipment Required

The following test equipment is required for performing this RCT procedure:

- General purpose oscilloscope: Tektronix model 5304/D40 or equivalent.
- Rms voltmeter, Hewlett-Packard model 427A or equivalent.
- Cable, 50 ohm shielded with BNC plugs at either end, GenRad 726-C or equivalent (four required).
- Tee connector, BNC-type (two required).
- Shorted BNC-type connector plugs (one required for test of Remote Communications Interface option, 15 required for test of 16-Channel Selector option).
- Cable, 50 ohm shielded with 3-wire audio plug at one end and BNC-type connector at the other end, GenRad part number 1923-2164 or equivalent (one required for test of 16-Channel Selector option).

4.3 PRELIMINARY PROCEDURES

The preliminary procedures described here are necessary prerequisites for the successful performance of the RCT. These preliminary procedures include making the required signal connections, loading RT-11 and the RANDOM program, and making certain menu parameter selections. Perform these operations in the order shown.

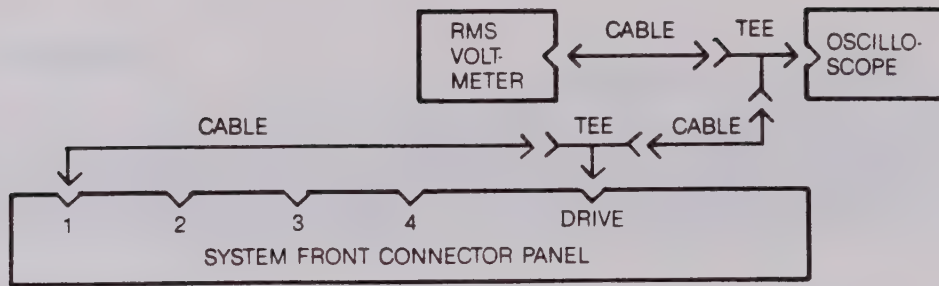
4.3.1 Signal Connections

- Step 1. Check that the clock signal connection for the system D/A has been made (see paragraph 1.6.3).
- Step 2. Connect the DRIVE output to channel 1 input and to the monitoring test equipment as shown in Figure 4-1A, using the cables and tee connectors.
- Step 3. If the 16-channel selector unit is to be tested, all inputs except the channel in use must be grounded with shorted BNC plugs. Check that the power cable to the unit has been connected (see paragraph 1.6.4).
- Step 4. If the Remote Communications Interface is to be tested, check that the cables have been connected between the interface unit and the system (see paragraph 1.6.5).

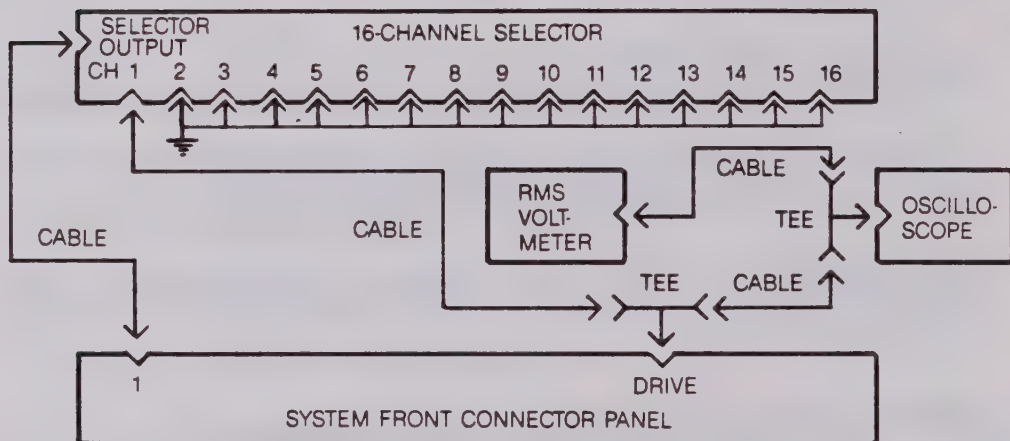
4.3.2 Software Loading and Initial Menu Parameter Selections

Load the RT-11 operating system. Be sure that the file RANDOM.RN is not on the disk. Then load the RANDOM program. When the program is in execution with the menu active, set the function, tolerance bands, type, and parameter menu parameters to the selections indicated below. The other parameter selections already have the desired values and so need not be changed.

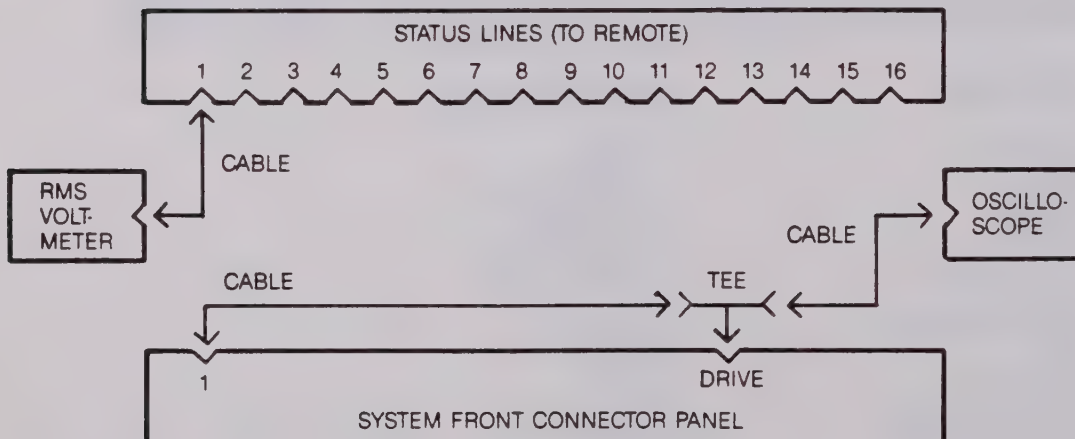
<u>Parameter</u>	<u>Required Selection</u>
Function	TEST
Mode	AUTOMATIC
Spectrum	CONTROL
Display	STANDARD
Vertical Scale	6 DECADES
Max Value	0.1
Horizontal Scale	LINEAR
Graph	LINE
Auto Erase	ON
Tolerance Bands	ALARM
Cross-Hatch	OFF
Type	EXPONENTIAL
Parameter	8



A. Signal Connections for 1, 2 or 4 Channel System



B. Signal Connections for Optional 16-Channel Selector



C. Signal Connections for Optional Remote Communications Interface

Figure 4-1. RCT Signal Connections

4.4 TEST PROCEDURES

4.4.1 Drive Signal Generation Test

The following steps demonstrate that the RANDOM program properly generates a random drive signal and adjusts its frequency content so that when the signal is connected to input channel 1, the control spectrum conforms to a pre-selected reference spectrum.

The test setup parameters used for this test are included in the program as load time values and do not require modification. A list of these parameter values is given in Figure 3-5.

To perform the drive signal operation test, proceed as follows:

- Step 1. Verify that all preliminary procedures have been performed.
- Step 2. Turn on the test equipment and adjust it to be able to observe a 40 mV rms signal.
- Step 3. Press the EXECUTE key. The system generates the message LOOP CHECK STARTED and automatically performs a loop check. This involves generation of a drive signal for less than a five second period and that reaches a peak level of about 100 mV.

Observe the loop check signal on the oscilloscope. After the signal terminates, the program should output the message LOOP OK. The test should then begin running at low level, with a display of the control spectrum and the alarm limit tolerance bands on the CRT. Proceed to step 4.
- Step 4. If the program generates the message OPEN CTL LOOP — CH 1, proceed to step 17. If the program generates the message NOISE ON SIGNAL —CH 1, proceed to step 18.
- Step 5. Disconnect the input signal from channel 1 and observe that the program generates the message SHUTDOWN INITIATED, followed by an audible tone and the message TEST ABORTED — SEE POST TEST when shutdown is complete.
- Step 6. Press the MENU key, set the function parameter to POST-TEST, and press the EXECUTE key. The system erases the CRT and displays a post-test message as shown in Figure 4-2.
- Step 7. Enter N followed by RETURN at the keyboard to leave the post-test function. Then reconnect the input signal to channel 1. Set the menu function parameter to TEST, and press EXECUTE. The CRT erases, a loop check performs, and the messages LOOP CHECK STARTED and LOOP OK display. The system begins to output a low level drive signal that increases rapidly in amplitude to a value of 24 to 28 mV, and a spectrum display showing the control spectrum displays on the CRT. Observe after about 20 seconds that most or all of the control spectrum points of the display fall within the ± 6 dB alarm limit tolerance bands. See Figure 4-3.

GR2511
RECEIVING CHECKOUT TEST PARAMETERS
RANDOM VIBRATION CONTROL

Bw: 2000.
Res: 200.0
Ref Grms: 3.194
Ctl Ch: 1
Aux Ch: 0

0:20:2
15-Nov-84

ABORTED
Ctl Signal Loss!
Ch 1

Low Level (-dB): -20.00
Time (hr, min, sec): 0,2,45

Test Time (hr, min, sec): 0,0,0
Remaining Time (hr, min, sec): 0,2,0

Max Error 3.581 dB at 10.00 Hz

Repeat Post-Test Message? (Y/N):

Figure 4-2. Post-Test Message after Loss of Control Signal

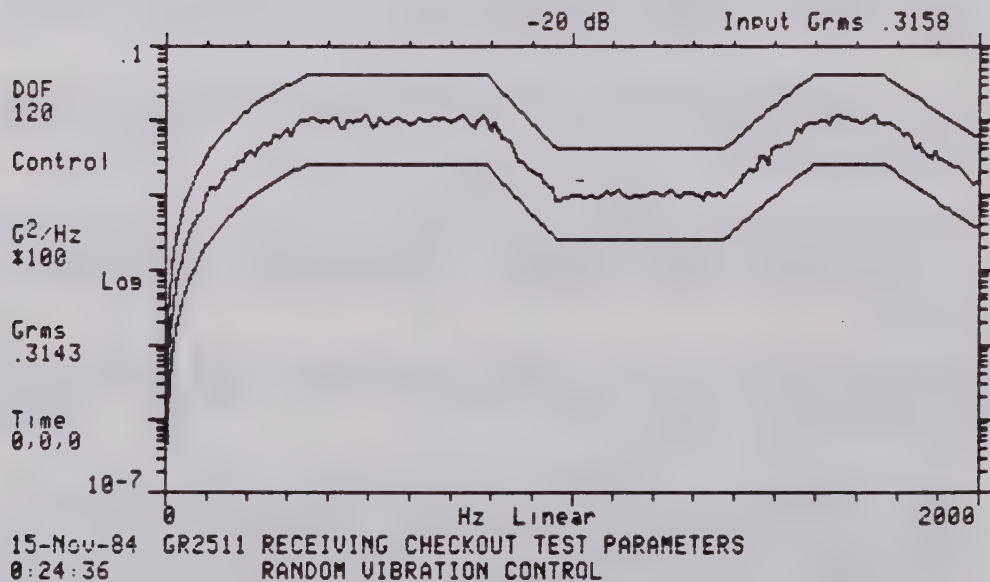


Figure 4-3. Control Spectrum with Low Level Drive Signal

- Step 8. Press MENU, set the spectrum parameter to MONITOR, and press EXECUTE. A new display showing the monitor spectrum appears. Observe that all points of the monitor spectrum are within the tolerance bands. See Figure 4-4.
- Step 9. Observe the rms voltmeter. Because of the random nature of the drive signal the meter reading fluctuates, but the average value of the signal should be 25 (± 2.5) mV.
- Step 10. Press the up-arrow ($\uparrow$) and observe that the dB value of the drive signal level (located above the top center of the display graticule on the CRT) increases to 0 dB in 2 to 4 seconds. When the drive level reaches 0 dB (full level) start timing the test.
- Step 11. Observe that the rms voltmeter indicates 310 (± 31) mV.
- Step 12. Continue timing the test and observe that at 1 minute and 55 seconds (five seconds before test completion) an audible tone sounds. Five seconds later the test shuts down with the drive signal level decreasing smoothly.

The test time at full level should be 2 minutes ± 3 seconds. If the test time deviates more than 3 seconds from 2 minutes, the system may have timing generator problems to resolve.

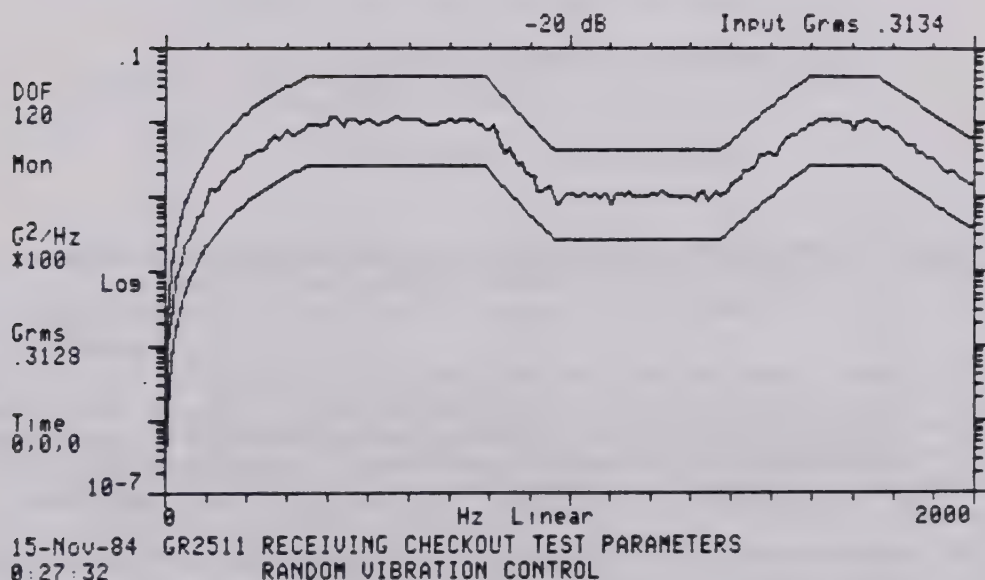


Figure 4-4. Monitor Spectrum with Low Level Drive Signal

- Step 13. Observe that when the test shuts down, the program displays the message TEST COMPLETED — SEE POST-TEST and outputs an audible signal.
- Step 14. Press MENU, set the function parameter to POST-TEST, and press EXECUTE. A post-test message similar to that shown in Figure 4-5 displays on the CRT.

```

GR2511
RECEIVING CHECKOUT TEST PARAMETERS
RANDOM VIBRATION CONTROL
Bu: 2000.
Res: 200.0
Ref Grms: 3.194
Ctl Ch: 1
Aux Ch: 0

0:32:6
15-Nov-84

Completed

Low Level (-dB): -20.00
Time (hr, min, sec): 0,3,46

Test Time (hr, min, sec): 0,2,0
Remaining Time (hr, min, sec): 0,0,0

Max Error 1.308 dB at 180.0 Hz

Repeat Post-Test Message? (Y/N):

```

Figure 4-5. Typical Post-Test Message for Drive Signal Generation Test

- Step 15. Enter N and RETURN to leave the post-test function. Set the cross-hatch parameter to ON, and press EXECUTE. The spectrum display showing the final monitor spectrum generated during the test redisplay, and the axis tic marks extend as dotted lines across the display graticule to form an interior cross-hatch. This display is shown in Figure 4-6.
- Step 16. Observe that all points of the monitor spectrum fall within the tolerance bands, and that the grms value displayed to the left of the graticule is between 3.12 and 3.30.
- Step 17. Proceed to the maximum control bandwidth test in paragraph 4.4.2.

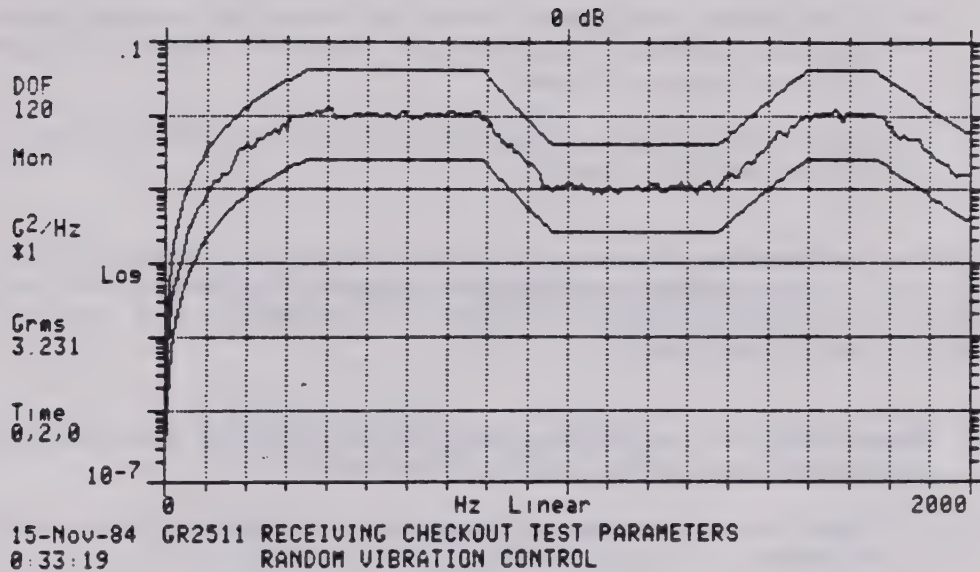


Figure 4-6. Monitor Spectrum with Cross-Hatch Following Drive Signal Generation Test

Note: Do not perform step 18 unless the system outputs the message OPEN CTL LOOP — CH 1 in step 3. This message indicates that the system is not detecting an input signal on channel 1, and the following step is intended to determine the cause of the problem.

Step 18. Press the MENU key, set the function parameter to TEST, and press the EXECUTE Key. A loop check signal should be observable on the oscilloscope. It should increase smoothly to a peak value of about 100 mV and then decrease. Repeat this step until the following points are resolved:

- Check the signal cables and connections to ensure that they are not defective.

- If the problem persists, check and correct as required the signal generation equipment of the system, including the digital-to-analog convertor, attenuator, output filter, and timing generator.
- If the problem still persists, check and correct as required the data acquisition hardware including input amplifiers, filters, analog-to-digital convertors, etcetera.
- Resolve the problem by means of the above. Then return to step 3 to continue the RCT procedure.

Note: Do not perform step 19 unless the system outputs the message NOISE ON SIGNAL — CH 1. This message indicates that the system detected an input signal on channel 1 in the absence of a drive signal. The following step is intended to establish the cause of the situation.

Step 19. Press MENU, set the function parameter to TEST, and press EXECUTE. Repeat this step until the problem is resolved.

- Check the signal cables and connections to ensure that they are not defective.
- If the problem persists, disconnect the test equipment from the DRIVE - Channel 1 loop and repeat. If the problem no longer occurs, repair or replace the test equipment, reconnect it, and repeat this step.
- If the problem still persists, check and connect as required the A/D and D/A hardware. When the problem is resolved return to step 3 to continue the RCT procedure.

4.4.2 Maximum Control Bandwidth Test

The following steps verify that the system operates at its maximum control bandwidth. The test parameters are set up to specify the maximum bandwidth and the test is run at full level until it completes normally. To perform the maximum bandwidth test, proceed as follows:

Step 1. Press the MENU key. Verify that the function parameter indicates STANDBY. If not, press the ABORT key and observe that the function selection changes to STANDBY.

- Step 2. Set the function parameter to SETUP and press the EXECUTE key.
- Step 3. Perform the following program generated setup dialog by entering the underlined responses shown below. Terminate each response by pressing the RETURN key.

```

Enter Parameters? (Y/N): N
Connections? (Y/N/L/U): Y

Line #: 4
Resolution 100/200/400/600/800: 400
Frequency Increment (Hz): 5.000
Grms=3.197

Line #: 3
Bandwidth: 8000
Bandwidth: 8000
Frequency Increment (Hz): 20.00
Grms=3.238

Line #: 13
Final Slope (dB/oct): -12
Frequency Increment (Hz): 20.00
Grms=3.889

Line #: 0

List? (Y/N): N
Save Parameters? (Y/N): N

```

- Step 4. Following the last response the menu automatically displays. Observe that the function parameter indicates STANDBY. Verify that the menu parameters listed below have the selections indicated. If not, make the selections.

<u>Menu Parameter</u>	<u>Selection</u>
Mode	AUTOMATIC
Spectrum	MONITOR
Graph	LINE
Auto Erase	ON
Tolerance Bands	ALARM or ABORT
Cross-Hatch	OFF

- Step 5. Set the function parameter to TEST and press the EXECUTE key.
- Step 6. Observe that the system performs a loop check and displays the message LOOP OK.

- Step 7. Observe that the system outputs a drive signal at low level (-20 dB) and that the monitor spectrum equalizes after about five loops so that it falls within the ± 6 dB alarm tolerance bands as shown in Figure 4-7.

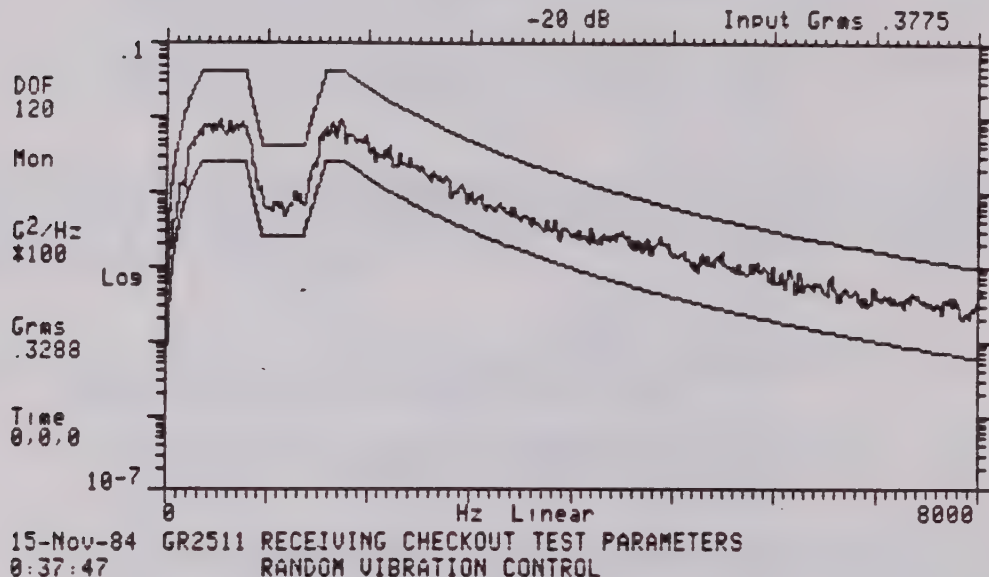


Figure 4-7. Monitor Spectrum at Low Level for Maximum Bandwidth Test

- Step 8. Press the $\uparrow$ key and allow the test to run to completion. The test duration is approximately 2 minutes. While the test is at full level (0 dB) the rms voltmeter reading should be 390 (± 39) mV.
- Step 9. At the conclusion of the test, the system generates the message TEST COMPLETED — SEE POST-TEST. Press MENU, set the function parameter to POST-TEST, and press EXECUTE. The system produces a post-test message similar to that shown in Figure 4-8.
- Step 10. Enter N followed by RETURN to exit from the post-test function.
- Step 11. Proceed to the multi-channel test of paragraph 4.4.3.

```

GR2511
RECEIVING CHECKOUT TEST PARAMETERS
RANDOM VIBRATION CONTROL
- Bw: 8000.
  Res: 400.0
  Ref Grms: 3.889
  Ctl Ch: 1
  Aux Ch: 0

0:42:50
15-Nov-84

Completed

Low Level (-dB): -20.00
Time (hr, min, sec): 0,2,45

Test Time (hr, min, sec): 0,2,0
Remaining Time (hr, min, sec): 0,0,0

Max Error 2.160 dB at 20.00 Hz

Repeat Post-Test Message? (Y/N):

```

Figure 4-8. Post-Test Message for Maximum Bandwidth Test

4.4.3 Multi-Channel Tests

The multi-channel tests are performed only for those systems having more than one analog input channel, or for systems that include the 16-channel selector unit. This test demonstrates the performance of the system using control channels other than channel 1. Proceed as follows:

- Step 1. If the system being tested contains input channel 2, continue with paragraph 4.4.3.1.
- Step 2. If the system does not contain channel 2 but does contain the 16-channel selector, go to paragraph 4.4.3.4.
- Step 3. If the system contains neither channel 2 nor the 16-channel selector, skip the multi-channel tests and proceed to paragraph 4.4.4.

4.4.3.1 Channel 2 Test.

- Step 1. Move the cable from channel 1 input to the channel 2 input (refer to Figure 4-1A).
- Step 2. Press MENU. Verify that the function parameter indicates STANDBY. If not, press the ABORT key and observe that the program goes to STANDBY state.
- Step 3. Set the function parameter to SETUP and press EXECUTE.
- Step 4. Perform the following setup dialog by entering the underlined responses shown. Terminate each response by pressing RETURN.

```

Enter Parameters? (Y/N): N
Corrections? (Y/N/L/U): Y
Line #: 24
Control Channels: 2
Accel Sens (mV/g):
Ctl Ch 2: 100
Extremal Control? (Y/N): N
Line #: 0
List? (Y/N): N
Save Parameters? (Y/N): N

```

- Step 5. Following the last response the menu display re-appears. Observe that the menu parameter selections shown in paragraph 4.4.2, step 4, are still in effect. Set the function parameter to TEST, and press EXECUTE.
- Step 6. Observe that the system performs a loop check and displays the message LOOP OK.
- Step 7. Observe that the system outputs a drive signal at low level (-20 dB), and that the monitor spectrum is brought within the tolerance bands after four or five loops.
- Step 8. Press the ↑ key and allow the test to run to completion (about 2 minutes). While the test is at full level (0 dB) the rms voltmeter should indicate 390 (± 39) mV.

Step 9. Following the TEST COMPLETED message, press MENU, set the function parameter to POST-TEST, and press EXECUTE. The system produces a post-test message similar to that of Figure 4-8. Enter N followed by RETURN to leave the post-test function.

Step 10. Proceed as follows depending on the options present in the system being tested:

If input channels 3 and 4 are present, go to paragraph 4.4.3.2.

If channels 3 and 4 are not present, but the 16-channel selector is present, go to paragraph 4.4.3.4.

If neither channels 3 and 4, nor the 16-channel selector are present, go to paragraph 4.4.4.

4.4.3.2 Channel 3 Test.

Step 1. Move the cable from channel 2 input to channel 3 input.

Step 2. Repeat steps 2 through 9 of paragraph 4.4.3.1. In step 4 respond to the control channels message with 3.

Step 3. Proceed to paragraph 4.4.3.3.

4.4.3.3 Channel 4 Test.

Step 1. Move the cable from channel 3 input to channel 4 input.

Step 2. Repeat steps 2 through 9 of paragraph 4.4.3.1. In step 4 respond to the control channels message with 4.

Step 3. If the system includes the 16-channel selector, proceed to paragraph 4.4.3.4. Otherwise go to paragraph 4.4.4

4.4.3.4 16-Channel Selector Test.

Step 1. Press MENU, set the function parameter to SETUP, and press EXECUTE.

Step 2. Perform the following setup dialog by entering the underlined responses shown. Terminate each response by pressing RETURN.

```

Enter Parameters? (Y/N): N
Corrections? (Y/N/L/U): Y
Line #: 21
  Test Time (hr, min, sec): 0,0,30
Line #: 23
  16-Ch Selector? (Y/N): Y
Line #: 24
  Control Channels: 1
  Accel Sens (mV/g):
    Ctl Ch 1: 100
  Extremal Control? (Y/N): N
Line #: 0
List? (Y/N): N
Save Parameters? (Y/N): N

```

- Step 3. Connect the DRIVE output to the CH 1 connector on the selector unit, and install a cable between the Selector Output connector on the selector and channel 1 input on the system chassis, as shown in Figure 4-1B.
- Step 4. Verify that BNC shorting plugs are installed at the CH 2 through CH 16 connectors on the selector unit.
- Step 5. Repeat steps 5 through 9 of paragraph 4.4.3.1. Observe that the test time in step 8 of 4.4.3.1 is 30 seconds instead of 2 minutes.
- Step 6. Move the cable to the next input connector on the 16-channel selector unit (from CH n to CH n+1) and move the BNC shorting plug from CH n+1 to CH n.
- Step 7. Repeat step 2 above but respond to line 24 with n+1, the input number of the 16-channel selector to which the signal is connected.
- Step 8. Repeat steps 5 through 7 until all input connectors on the 16-channel selector have been tested.
- Step 9. Reconfigure the signal connections to conform with that shown in Figure 4-1A. Remove all BNC shorting plugs from the 16-channel selector.
- Step 10. Press MENU, set the parameter to SETUP, and press EXECUTE.

Step 11. Perform the following setup dialog by entering the underlined responses shown. Terminate each response by pressing the RETURN key.

```

Enter Parameters? (Y/N): N
Corrections? (Y/N/L/U): Y
Line #: 23
  16-Ch Selector? (Y/N): N
Line #: 24
  Control Channels: 1
  Accel Sens (mU/g):
    Ctl Ch 1: 100
  Extremal Control? (Y/N): N
Line #: 0
List? (Y/N): N
Save Parameters? (Y/N): N

```

Step 12. Proceed to paragraph 4.4.4.

4.4.4 Remote Communications Interface Tests

If the system being tested includes the optional Remote Communications Interface, continue with paragraph 4.4.4.1.

If the system does not include the remote interface, press MENU, set the function parameter to EXIT, and press MENU. Control then leaves the RANDOM program and returns to the operating system. This concludes the RCT.

4.4.4.1 Command Lines Test. The following steps demonstrate the performance of the command (input) lines of the Remote Communications option. In this test a listing of the setup parameters is obtained to verify the presence of the option. Each command line of the option is then tested as an external alarm line to verify proper operation.

Step 1. Press MENU. Verify that the function parameter indicates STANDBY. If not, press the ABORT key and observe that the program goes to standby state.

- Step 2. Set the function parameter to SETUP and press EXECUTE.
- Step 3. Perform the following setup dialog by entering the underlined responses shown. Terminate each response by pressing the RETURN key.

```
Enter Parameters? (Y/N): N
Corrections? (Y/N/L/U): N
List? (Y/N): Y
```

```
1 Test Id: GP2511
  Comments: RANDOM VIBRATION CONTROL
2 Heading: RECEIVING CHECKOUT TEST PARAMETERS
3 Bandwidth: 8000.
```

(A list of parameter similar to those shown in Figure 3-3 will display on the CRT.)

```
32 Loop-Check Max Drive (Volts): .1000
    Print Gain and Pause after Loop-Check? (Y/N): N
33 AC Coupling? (Y=AC/N=DC): Y

Corrections? (Y/N/L/U): N
List? (Y/N): N
Save Parameters? (Y/N): N
```

- Step 4. Observe the last few lines of the parameter listing. If the system contains the Remote Communications Interface the listing should include the following statement:

```
34 ALARM LINES:
    ABORT LINES:
```

If this message does not occur in the listing but the interface should be present, verify that the interface card is installed in the system and is properly seated. Resolve this before continuing with the test.

- Step 5. Locate the remote communications panel. Remove and disconnect any external cables connected to the command lines and status lines. Verify that the internal cables connecting the panel to the system are in place.
- Step 6. Connect a BNC shorting plug to the command (FROM REMOTE) line input connector 1.
- Step 7. Press MENU, set the function parameter to SETUP, and press EXECUTE.
- Step 8. Perform the following setup dialog by entering the underlined responses shown. Terminate each response by pressing RETURN.

```

Enter Parameters? (Y/N): N
Corrections? (Y/N/L/U): Y
Line #: 34
Alarm Lines: 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16
Abort Lines: 0
Response 1=Open, 0=Short: 0

Line #: 0

List? (Y/N): N
Save Parameters? (Y/N): N

```

- Step 9. Press MENU, set the function parameter to TEST, and press EXECUTE.
- Step 10. Observe that the system performs a loop check, displays the message LOOP OK, and then outputs a drive signal at low level.
- Step 11. Observe that once per loop the system displays the message ALARM LINES: 1 in the message block area located in the upper left corner of the CRT. This verifies operation of command input 1.
- Step 12. Disconnect the shorted connector plug and observe that the ALARM LINES message stops.
- Step 13. Move the BNC shorting plug to the next command line. Observe that the system now displays ALARM LINES: n once per loop, where n is the number of the shorted command line.

- Step 14. Repeat steps 12 and 13 until all 16 command lines have been tested.
- Step 15. Remove the shorted plug from the remote interface unit and note that no alarm messages occur.
- Step 16. Press the ABORT key. Then press the MENU key and observe that the program is in STANDBY state.

4.4.4.2 Status Lines Test. The following steps demonstrate the performance of the status (output) lines of the Remote Communications option. In this test the RANDOM program is placed into a series of states with known status. While the program is in each state the status lines are interrogated and their condition (high or low) may be compared to the expected program status. Interrogation of status lines is performed a total of six times. At each interrogation one or more of lines 1 through 7 should be high. The program does not use lines 8 through 16; these lines should be low at all times.

If the expected status line levels are not achieved at any step of this test, a problem exists with the Remote Communications interface board or test panel. Correct the problem before proceeding with the test.

- Step 1. Disconnect the oscilloscope from the DRIVE signal and the rms voltmeter, and connect it to status line 1 on the remote interface, as shown in Figure 4-1C.
- Step 2. Adjust the oscilloscope to be able to observe a signal of +5V peak.
- Step 3. Connect the oscilloscope to each of status lines 1 through 16 and observe the level of each line. Lines 1, 6 and 7 should be high, all other lines should be low. This indicates the program is in standby with an abort indication, caused by action of step 4.4.4.1, step 16.
- Step 4. Press MENU, set the function parameter to SETUP, and press EXECUTE.
- Step 5. Perform the following setup dialog by entering the underlined responses shown. Terminate each response by pressing RETURN.

```

Enter Parameters? (Y/N): N
Corrections? (Y/N/L/U): Y
Line #: 18
Level Increment (dB): 20
Line #: 21
Test Time (hr, min, sec): 0,20,0
Line #: 34
Alarm Lines: 0
Abort Lines: 0
Line #: 0
List? (Y/N): N
Save Parameters? (Y/N): N

```

- Step 6. Observe that the menu displays. Set the mode parameter to MANUAL and the function parameter to TEST, and press EXECUTE.
- Step 7. Observe that the program performs a loop check and displays the messages LOOP CHECK STARTED followed by LOOP OK. The program then outputs a drive signal at low level (-20 dB). Observe the monitor spectrum as it equalizes to the reference spectrum.
- Step 8. Connect the oscilloscope to each of status lines 1 through 16 and observe the level of each line. Line 3 should be high, all other lines should be low. (Indicates test function being executed, with low level drive and no alarms.)
- Step 9. Press the up-arrow (↑) key and observe that the drive signal rises from low level to full level (0 dB).
- Step 10. Press MENU, set the test modification parameter to DRIVE UPDATE, and press EXECUTE.
- Step 11. Press the MODIFY key. The query message Drive Update (1=ON, 0=OFF): flashes in the query block area of the CRT.
- Step 12. Connect the oscilloscope to each of status lines 1 through 16 and observe the level of each line. Lines 2 and 4 should be high, all other lines should be low. This indicates that the program is in a test/hold state with the drive signal at full level awaiting your response to the query.

- Step 13. Enter 1 followed by RETURN to respond to the Drive Update query. Observe that the test continues.
- Step 14. Connect the oscilloscope to each of status lines 1 through 16 and observe the level of each line. Line 4 should be high and all other lines should be low. (Indicates that program is in test state with drive signal at full level.)
- Step 15. Disconnect the signal cable from the channel 1 input connector.
- Step 16. Observe that the messages SHUTDOWN INITIATED and TEST ABORTED — SEE POST-TEST display. The program is now in standby state.
- Step 17. Connect the oscilloscope to each of status lines 1 through 16 and observe the level of each line. Lines 1 and 7 should be high, all other lines should be low. This indicates that the program is in standby with an abort condition of control signal loss.
- Step 18. Verify that the signal cable is still disconnected from the channel 1 input. Press MENU, set the function parameter to LOOP-CHECK, and press EXECUTE.
- Step 19. Observe that the message LOOP CHECK MAX DRIVE (VOLTS): flashes on the CRT. Enter .1 followed by RETURN.
- Step 20. Observe that the program displays the message LOOP CHECK STARTED, followed by the message OPEN CONTROL LOOP —CH 1. The program is now in standby state.
- Step 21. Connect the oscilloscope to each of channels 1 through 16 and observe the level of each line. Lines 1 and 5 should be high, all other lines should be low. (Indicates program is in standby with an abort condition of open control loop in loop check.)
- Step 22. Press MENU, set the function parameter to EXIT, and press EXECUTE. Observe that control leaves the RANDOM program and returns to the operating system.
- Step 23. Disconnect the test equipment from the system. This concludes the RCT.

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GenRad

2501-0150
November 1979

Change 1
March 1980

Change 2
July 1980

Change 3
May 1981

Change 4
May 1982

Change 5
March 1983

Change 6
March 1986

ISAP

INTERACTIVE SIGNAL ANALYSIS
PROGRAM, VERSION 5.3

OPERATING MANUAL

Publication No. 2501-0150
Copyright 1981, GenRad, Incorporated
Printed in U.S.A.

GENRAD, INCORPORATED
Structural Test Products
510 Cottonwood Drive
Milpitas, CA 95035

Telephone (408) 946-6960

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REVISION PAGE

Original	November	1979		
Change 1	March	1980		PRB 3158
Change 2	July	1980	ISAP V2.0	ECN 2384
Change 3	May	1981	ISAP V3.0	ECN 2467
Change 4	May	1982	ISAP V4.0	ECN 2591
Change 5	March	1983	ISAP V5.0	ECN 2689
Change 6	March	1986	ISAP V5.3	ECN 3034

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SECTION I

DESCRIPTION AND GENERAL INFORMATION

1.1 SCOPE AND RELATED DOCUMENTS

This operating manual describes the functions and operation of the GenRad Interactive Signal Analysis Program (ISAP) software package, part number 2501-0650. It is designed to be run on the 2500 Series Systems under the Digital Equipment Corporation RT-11 operating system. Beginning with V03, ISAP will also run on the 2510 MicroModal Analyzer.

For a general description of the 2500 Series Systems and the RT-11 operating system refer to the 2500 Series Operating Manual, Form No. 2501-0100. For a general description of the 2510 MicroModal Analyzer refer to the 2510 Operating Manual, Form No. 2510-0100. The ISAP application software manual assumes that the user is thoroughly familiar with the system components, terminology, general hardware controls, connectors and basic software start up procedures as described in the 2500 System Operating Manual, Form No. 2501-0100 (or the 2510 Operating Manual, Form No. 2510-0100).

Section I provides a general overview of ISAP's features. Section II describes ISAP's special function keys and provides a step-by-step familiarization procedure that serves to acquaint the new user with the program organization and general operating procedures. Section III expands the operating instructions with detailed descriptions of the operational sequences and the functions and effects of the various setup parameters.

1.2 SOFTWARE SUPPLIED

For systems with floppy disk drives, the ISAP program and a minimum subset of the Run Time RT-11 operating system are supplied along with the GenRad utilities described in the 2500 Systems Operating Manual on one double density (DY) floppy disk, part number 2501-0650. For cartridge disk systems, the ISAP program included under the above part number is supplied along with any other application software and RT-11 on a cartridge disk. The required program files for ISAP operation are:

ISAP.SAV	Basic Operating Program,
ISAP.DEF	Default Setup File.

NOTE

If the ISAP.DEF file is not on the disk, it will be created by the ISAP.SAV program upon the run ISAP command.

1.3 DESCRIPTION

ISAP is a multi-channel spectral analysis software package which uses digital fast Fourier transform and other processing techniques to perform accurate analysis of analog input signals. ISAP provides the following single-channel processing functions:

- (1) Sampled Data
- (2) Instantaneous Input Spectrum
- (3) Auto Spectrum
- (4) Auto Correlation
- (5) Amplitude Probability Density
- (6) Waveform Averaging

Single-channel functions may be performed on any one channel, on two channels, or on four channels simultaneously (if four channels are available).

The two-channel functions available with ISAP are:

- (1) Cross Correlation
- (2) Transfer Characteristics
 - Frequency Response
 - Coherence
 - Cross Spectrum
 - Impulse Response
 - Co-Quad

The ISAP program is entirely menu-driven. All setup parameters and operations are controlled by selections from displayed menus, or by entry of parameter values in response to queries from the various setup dialogs. There are no external panel controls or indicators other than the normal system keyboard. Certain key functions that are special for the ISAP program are listed in section II. Parameters which are selectable by the operator include function, channel, frequency range, resolution (number of spectral lines), averaging mode, voltage sensitivity, engineering units, display formats (including "ZOOM" expanded display*), triggering mode, Hanning weighting, impact test windowing, autoranging, and data rejection. Sampled data of the signal input to the selected channel(s) and instantaneous spectra of sampled data may be displayed on the screen at any time by pressing certain special function keys (see table 2-1) on the keyboard. Both setup parameters and processed data can be written to disk files for storage and later recall. Beginning with version V03, ISAP can also write and read transfer function data files that are compatible with GenRad/SDRC MODAL structural analysis programs.

*The ZOOM processing is operable only on systems which contain the ZOOM hardware, which is standard on all current systems but might not be on older systems.

Table 1-1. Features, Characteristics, and Specifications

Hardware

Input Channels:	Two or four
Input Coupling:	Input dc coupling or ac coupling by high pass filter (3dB cutoff less than 1 Hz).
Input Range:	8 selectable voltage ranges from ± 0.125 to ± 16 volts peak.

NOTE: Any input greater than ± 10 volts will cause an analog-to-digital sub-system (ADS) overload, invalidating any data acquired during the overload.

Maximum Full
Scale Value:

Selectable as follows:

<u>Max Volts</u>	<u>dB</u>
16	+24
8	+18
4	+12
2	+ 6
1	0
.5	- 6
.25	-12
.125	-18

Input Trigger:	Adjustable level with external analog or digital trigger.
Source:	CHA, CHB, CHC (if four channel system), External Analog or External Digital.
Level:	+FS +80% +60% +40% +20% +10% + 5% > 0% - 5% -10% -20% -40% -60% -80% -FS NOTE: The maximum range for EXT ANALOG input is ± 2 V. If EXT ANALOG is selected, these percentages are relative to that ± 2 V range, and do not depend on sensitivity setting. (For systems shipped prior to June 1981, the fixed EXT ANALOG trigger range is ± 10 V.) Also note that the EXT ANALOG does not trigger at the zero crossing (0%) if the triggering signal never crosses from positive to negative or vice versa (e.g., impact hammer impulse).
Slope:	Positive, negative or either.
Delay:	Selectable from -200% to +100% of frame size.

Table 1-1. Features, Characteristics, and Specifications (Continued)

Setup

Frequency Range:	Selectable from 10 Hz to 25,000 Hz (baseband and overlap).
Sampling Rate:	Set to 2.56 times the desired baseband frequency range.
Spectral Resolution:	See Table 1-2.
Frame Size:	See Table 1-2.

ZOOM Sampling

Maximum Frequency:	7 kHz for a single channel function, 3 kHz for a two channel function and 1.5 kHz for a four channel function.
Spectral Resolution:	50, 100, 200, 300, 400 or 800 spectral lines.

Overlap Sampling

Overlap Factor:	2, 4, 8 or 16. The overlap factors available are a function of the frame size. For 400 line spectra the maximum factor is four; for 800 line, eight, etc.
-----------------	---

Auto Range

Lower Level:	Selectable from 0% to 80% of the maximum full scale value.
--------------	--

Table 1-2. Maximum Allowable Spectral Resolutions
or Frame Sizes

Function	32k Memory			64k Memory		
	1 Ch	2 Ch	4 Ch	1 Ch	2 Ch	4 Ch
Spectrum	1600	800	400	3200	3200	1600
Xfer Funct	N/A	400	200	N/A	1600	800
Cross Corr	N/A	1024*	256*	N/A	1024*	1024*
Auto Corr	1024*	1024*	512*	1024*	1024*	1024*
Ampl Prob	80	800	400	800	800	800
Wave Avg	2048*	1024*	512*	2048*	2048*	2048*

* Indicates frame size (time domain); all other entries are spectral resolutions (frequency domain).

SECTION II

OPERATOR FAMILIARIZATION

2.1 INTRODUCTION

This section provides a description of ISAP's special function keys, test equipment setup and operator familiarization procedure. This familiarization procedure provides a check that the system software and hardware are operating properly and also demonstrates the general organization and operation of the program to acquaint new users with its functions.

2.2 ISAP SPECIAL FUNCTION KEYS

Special functions for the ISAP program have been assigned to certain keys on the keyboard. Labels for special functions applicable only to ISAP are printed above the top row of keys on the keyboard. These labels assign new names to the ten numbered keys. The functions performed by these keys and other special function keys are described in Table 2-1.

Table 2-1. Special Function Keys

Key	ISAP Label	Function
1	MENU	Enters parameter setup menu mode and calls the top level menu to the screen. May be pressed at any time, including during menu selection, to return to the top level menu.
	DISPLAY	Pressing any of the following three keys (2,3,4) exits the menu setup mode.
2	SAMPLE DATA	Displays the current input signal. May be used at any time (does not invalidate processed data), except while averaging.

Table 2-1. Special Function Keys (Continued)

Key	ISAP Label	Function
3	INPUT SPCTRM	Displays the spectrum or spectra of current input data. May be used at any time (does not invalidate processed data), except while averaging.
	AVERAGING	The next three keys control the averaging process.
4	AVG	Displays processed data. If no valid data exists in memory, the sampled data will be displayed.
5	START	Starts the averaging process. Exits the menu mode, although the last menu printed may remain on the screen.
6	STOP	Stops averaging and processes the data. Used when exponential averaging was specified; may also be used with summation averaging if desired.
7	RESUME	Restarts averaging from the point where it was when the STOP key was pressed.
6	ARM TRIG	Manually arms trigger. Used when manual triggering was specified in the setup menu.
	CURSOR	The next two keys are used for the display cursor.
9	SINGLE	Sets or terminates expanded display sequence; used on averaged displays.
0	SIDE BANDS	Reserved for future use.
MARK		Used in menu mode to advance program to next menu. When in alphanumeric entry mode, erases previous value so new entry may be typed. The carriage return key (RETURN) is used to exit the alphanumeric entry mode. Used in expanded display mode to select minimum and maximum x-axis limits.
RETURN		In alphanumeric entry mode, pressed after the entry of new value to return to menu selection mode.
↑,↓		Tapped to move menu pointing cursor (>) up or down to select desired parameter in the menu mode or to increase/decrease input sensitivity during instantaneous displays, or scale offset during averaged displays.

Table 2-1. Special Function Keys (Continued)

Key	ISAP Label	Function
←,→		Tapped to move the graphic cursor left or right or to increase or decrease the time frame size or frequency during instantaneous display.
A,B,C,D		Pressed when viewing sampled data or input spectrum to select a channel for changing the magnitude or domain. May also be used to display valid averaged data on other channels for multi-channel functions.
W		When TIME domain averaging has been selected, striking this key displays the Waveform average for the channel last selected by A,B,C,D above. When Impact Windowing has been selected, striking this key causes the Windowed time data to be displayed in subsequent frames. Theraw time data display may be restored by striking the 'W' key again.
M		In the MODAL OUTPUT function, striking this key will return directly to the WRITE, RESP menu for entry of new response coordinate. Otherwise, sampled data is displayed.
NOTE		
When a Transfer Function has been processed, all of the following functions are available and may be selected for display by striking the keys listed below:		
A,B,C,D		Sets selected channel (if used) as the response channel and displays its auto spectrum.
T		Transfer Function (Bode plot)
G		Coherence Function
X		Cross Spectrum
I		Impulse Response
Q		Co-Quad plot (real, imaginary)

2.3 TEST EQUIPMENT AND SETUP

To perform the familiarization procedure, the following equipment is required:

- (1) Signal source such as a GR 1309-A oscillator or equivalent.
- (2) Cables and connectors as necessary to connect the signal source to two BNC input connectors.

Connect the signal source output to channels 1(A) and 2(B) connectors located on the front panel of the ADS unit. Adjust the signal course for a 500 Hertz sine wave, of less than $\pm 1V$.

2.4 CORRECTIONS AND ABORTS

Typing errors, if they are caught before entry by (CR) may be corrected with the BACKSPACE Key. If a typing error is noticed after it has been entered by (CR) or MARK, press the MENU Key, select the desired sub-menu and reenter all of the values. If it is necessary to return to the RT-11 monitor there are two procedures that may be used. They are:

- (1) The operator selects the top level menu by pressing the MENU Key, and then moves the cursor down to the EXIT option and presses the MARK Key. When this procedure is used, the program will save the current parameter setup in the default file (ISAP.DEF) on the default device, erase the screen, and exit to the RT-11 monitor.
- (2) The second method is to use the RT-11 abort command, CTRL/C, to return to the RT-11 monitor, then restart the ISAP program with the RUN ISAP command. Note that a CTRL/C abort clears all current setups and does not update the parameter default file.

2.5 FAMILIARIZATION PROCEDURE

This procedure provides a step-by-step introduction for new users on general system operation methods, commands, sequences, and illustrates several of the system functions. This procedure also serves as a checkout to demonstrate that the software and hardware are generally operating properly.

2.5.1 Program Start

- (1) Power up the system, mount the RT-11/ISAP operating disk, BOOT the system, and enter the date and time if desired, as shown below. If you are not familiar with this basic startup procedure, refer to the 2500 System Operating Manual, Form No. 2501-0100 (or the 2510 MicroModal Operating Manual, Form No. 2510-0100).

```

160100 150220 170220 060004
$DK
RT-11SJ  U04.00

.SET TT SCOPE

.SET EDIT TECO

.ASS TT: LP:

.R SYSINT

2500 V1 System
DAS Online
ADS - Initialized
  - 12-Bits
  - 8 Channels in Master Box
  - 8 Channels in Slave Box
Memory Size: 64k
9-Sep-82  Change Date? ---> 24-NOV-82
24-Nov-82
Please Enter The Time: 14:30:02
14:30:00

```

- (2) In floppy disk systems the startup command file will usually include the command to start the program. If it doesn't, or in cartridge disk systems that may include other software, enter the command .RUN ISAP to start the program. A startup display of sampled input data with annotated grid, similar to that shown in figure 2-1, will appear on the screen (assuming a 500 Hz, $\pm 1V$ input signal).

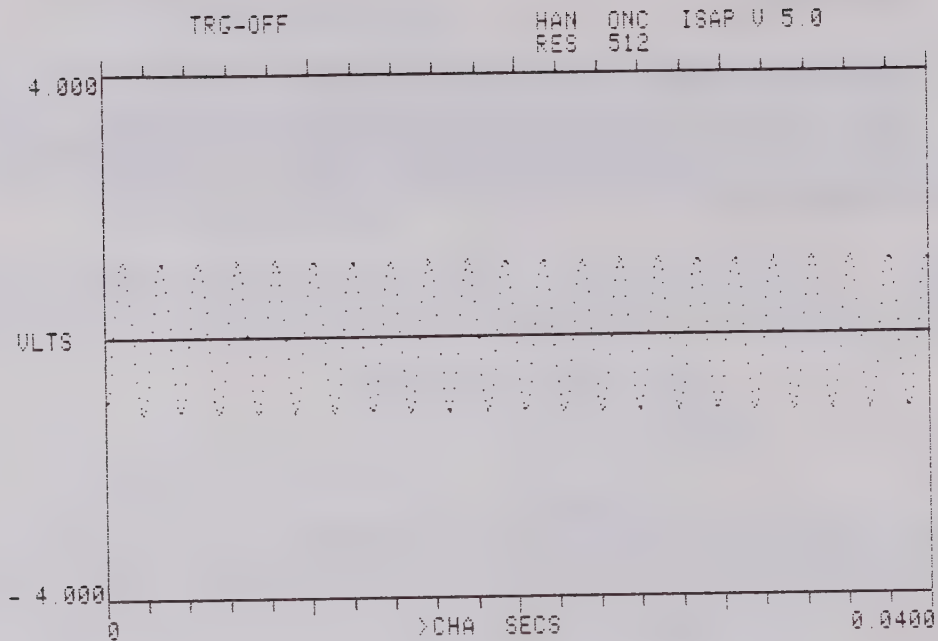


Figure 2-1. Typical Startup Display

2.5.2 Initial Test Setup

- (1) Press the MENU Key. The top level menu (MODIFY) will appear to the left of the display.
- (2) The cursor will appear positioned at FUNCTION. Press (MARK). The FUNCTION menu is printed.
- (3) Position the cursor at SPECTRUM (use the UP/DOWN arrow keys to position the menu cursor (>) at the desired menu option) and press MARK. A list of available channels is printed.
- (4) Position the cursor at AB and press MARK. The top level menu appears.
- (5) Go through the rest of the menu to setup the following initial test conditions. Note: operator entries in the following step are underscored.

MODIFY:
 FUNCTION
 > FREQUENCY (MARK)
SENSITIVITY
 TRIGGER
 DISPLAY
 AVERAGING
 WINDOWING
 ENG UNITS
 DISK I/O
 MODAL OUTPUT
 EXIT

SAMPLING:
 > BASEBAND (MARK)
ZOOM
 OVERLAP

FREQUENCY:
 10 Hz
 20 Hz
 50 Hz
 100 Hz
 200 Hz
 500 Hz
 1 kHz
 2 kHz
 > 5 kHz (MARK)
10 kHz
 25 kHz
 USER INPUT

OF LINES:
 > 100 (MARK)
200
 400
 800
 1600
 3200

MODIFY:
 FUNCTION
 FREQUENCY
 > SENSITIVITY (MARK)
TRIGGER
 DISPLAY
 AVERAGING
 WINDOWING
 ENG UNITS
 DISK I/O
 MODAL OUTPUT
 EXIT

AUTORANGE:

> OFF
ON

(MARK)

CHANNEL:

> A
B
C
D
DONE

(MARK)

MAX VOLTS DB:

16 +24
8 +18
4 +12
2 +6
> 1 0
.5 -6
.25 -12
.125 -18

(MARK)

COUPLING:

> AC
DC

(MARK)

CHANNEL:

> A
B
C
D
DONE

(MARK)

MAX VOLTS DB:

16 +24
8 +18
4 +12
2 +6
> 1 0
.5 -6
.25 -12
.125 -18

(MARK)

COUPLING:

> AC
DC

(MARK)

CHANNEL:

> A
B
C
D
DONE

(MARK)

MODIFY:
 FUNCTION
 FREQUENCY
 SENSITIVITY
 > TRIGGER (MARK)
DISPLAY
 AVERAGING
 WINDOWING
 ENG UNITS
 DISK I/O
 MODAL OUTPUT
 EXIT

TRIGGER:
 > OFF (MARK)
AUTO
 MANUAL

MODIFY:
 FUNCTION
 FREQUENCY
 SENSITIVITY
 TRIGGER
 > DISPLAY (MARK)
AVERAGING
 WINDOWING
 ENG UNITS
 DISK I/O
 MODAL OUTPUT
 EXIT

SET UP:
 INSTANT
 > AVERAGED (MARK)
DONE

CHANNEL:
 > A (MARK)
B
 AB

UNITS:
 > X**2 (MARK)
X**2/HZ
 X**2-SEC/HZ
 X

SCALE:
 > 100 DB (MARK)
80 DB
 60 DB
 40 DB
 20 DB
 LINEAR

LOG SCALING:

LOG

> DB (MARK)

SCALING:

FIXED

> AUTO (MARK)

FREQ SCALE:

> LIN-HZ (MARK)

LOG-HZ

LIN-CPM

LOG-CPM

SET UP:

INSTANT

AVERAGED

> DONE (MARK)

MODIFY:

FUNCTION

FREQUENCY

SENSITIVITY

TRIGGER

DISPLAY

> AVERAGING (MARK)WINDOWING

ENG UNITS

DISK I/O

MODAL OUTPUT

EXIT

DOMAIN:

> FREQ (MARK)TIME

AVG MODE:

> SUM (MARK)EXP

OF AVGS:

1

2

> 4 (MARK)

8

16

32

64

128

256

512

1024

DATA REJECT:
 OFF MANUAL
 OFF HIGH/LOW
 OFF DBL HIT
 >DONE (MARK)

MODIFY:
 FUNCTION
 FREQUENCY
 SENSITIVITY
 TRIGGER
 DISPLAY
 AVERAGING
 >WINDOWING (MARK)
ENG UNITS
 DISK I/O
 MODAL OUTPUT
 EXIT

HANNING:
 AUTO
 OFF
 >ON (MARK)

SCALING:
 >COMP (MARK)
 NO COMP

MODIFY:
 FUNCTION
 FREQUENCY
 SENSITIVITY
 TRIGGER
 DISPLAY
 AVERAGING
 WINDOWING
 >ENG UNITS (MARK)
DISK I/O
 MODAL OUTPUT
 EXIT

ENG UNITS:
 ON
 >OFF (MARK)

- (6) Press the SAMPLE DATA key and adjust the oscillator frequency as necessary so that the sine wave displayed is just less than 1 volt at approximately 500 hertz.
- (7) Press the INPUT SPCTRM key. The display which appears will be a spectrum of a single frame of input data, continuously updated (see figure 2-2).

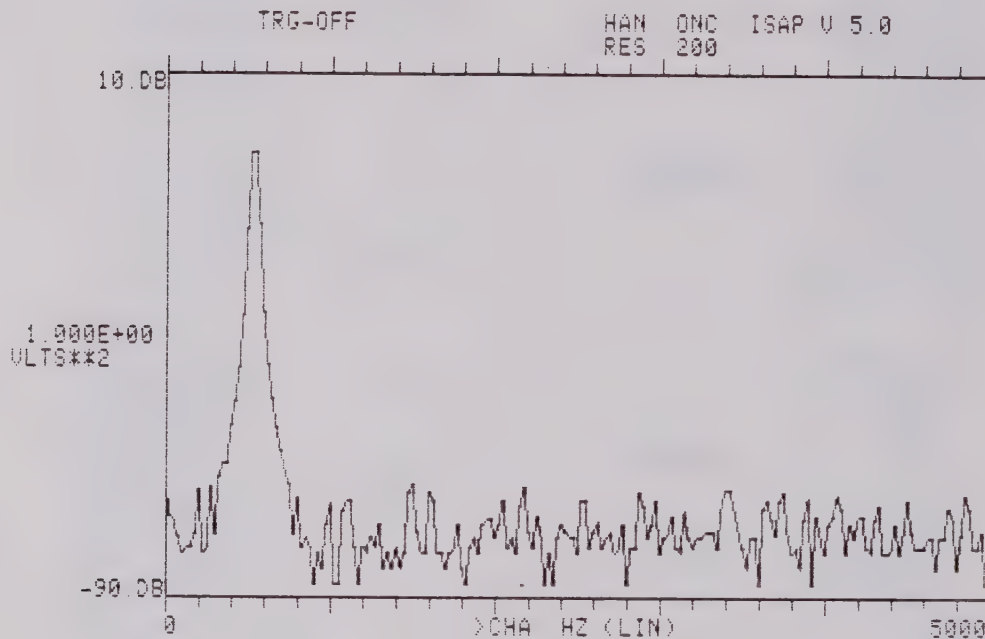


Figure 2-2. Instantaneous Spectrum

- (8) Press the START key. As the input data is processed the 0 in the annotation changes rapidly to 1, 2, 3, and then 4, the number of frames specified, and a spectrum of the processed data (see figure 2-3) is produced. Repeat as desired. Note that selected resolution is 100 lines versus the fixed 200 lines for INPUT SPCTRM, so that 500 Hz peak will not be as sharp.
- (9) Press MENU. The previous display remains on the screen but the top level menu is again at the left of the display.
- (10) Position the cursor at FUNCTION and press MARK. The first menu in the function series is printed, with the cursor positioned at SPECTRUM.
- (11) Position the cursor at XFER FNCTN (transfer function) and press MARK.
- (12) In the response channel menu, position the cursor at B, indicating that channel B will be the response channel and press MARK.

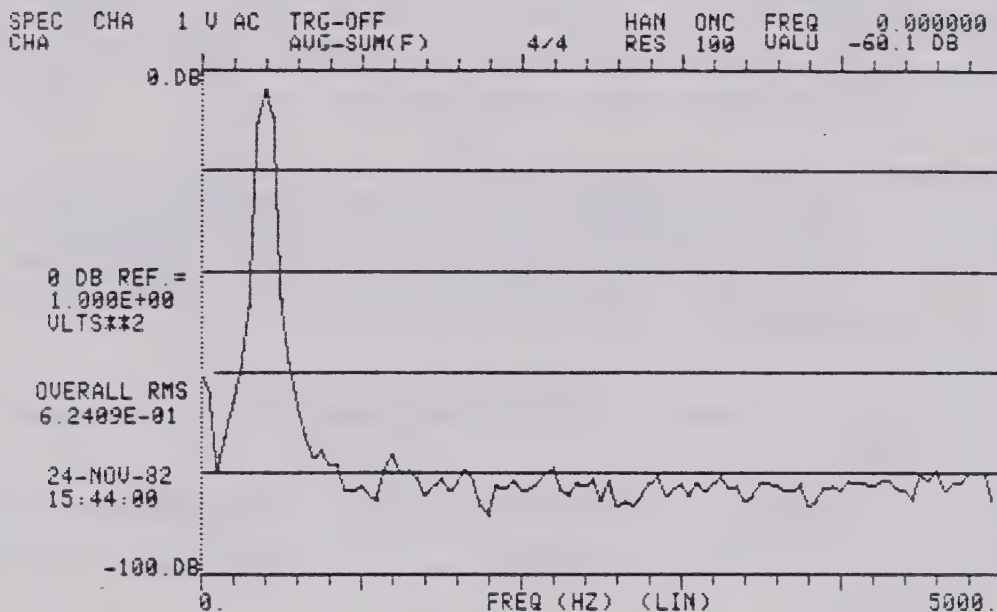


Figure 2-3. Processed Data Display

- (13) The REFERENCE CHANNEL menu appears; position the cursor at channel A and press MARK. The top level menu will appear.
- (14) Position the cursor at DISPLAY and press MARK.
- (15) Position the cursor at AVERAGED and press MARK.
- (16) Position the cursor at CROSS SPEC and press MARK. The program will present the units menu.
- (17) Position the cursor at X^{**2}/HZ and press MARK. The scale menu will appear.
- (18) Position the cursor at 100 DB (log) and press MARK.
- (19) The LOG SCALE menu appears; position the cursor at DB and press MARK.
- (20) The SCALING menu appears; position the cursor at AUTO and press MARK.
- (21) Position the cursor at LIN-HZ (frequency scale will be linear) and press MARK.

- (22) Position the cursor at DONE and press MARK. The program returns to the top level menu.
- (23) Position the cursor to FREQUENCY and press MARK to call the sampling menu.

NOTE

If the system contains zoom processing hardware, skip steps (24) and (25) below and perform steps Z(24) through Z(27) and then proceed with step (28). If the system does not contain zoom hardware, perform steps (24) and (25) and then skip to step (28).

- (24) Position the cursor at BASEBAND and press MARK. The frequency menu is printed.
- (25) Position the cursor at 1 kHz and press MARK. The resolution menu appears.
- Z(24) Position the cursor at ZOOM and press MARK. The expansion (zoom) menu is printed.
- Z(25) Position the cursor at CF (Center Frequency) and press MARK. The default value of 1000 is erased and the system goes into the alphanumeric entry mode.
- Z(26) Type in 500 and press RETURN. Note that the LOF and HIF (low frequency and high frequency) have been adjusted by the system due to the new center frequency.
- Z(27) Position the cursor at DONE and press MARK. The system asks for resolution (# of lines).
- (28) Position the cursor at 100 and press MARK. The top level menu appears.
- (29) Position the cursor at WINDOWING and press MARK. When the HANNING menu appears, position the cursor at OFF and press MARK. The program returns to the top level menu.
- (30) Press the START key to begin averaging. When completed, the display of processed data is produced, similar to that in figure 2-4. (Note: since the input signal to both channels is the same sine wave, the phase data in this example will not be meaningful except near the actual signal frequency. Also, if zoom processing is not in effect, the display will be somewhat different, covering the baseband range from 0 to 1000 Hz.)
- (31) Press the right and left arrow keys to position the graphic cursor at the peak and note the readout at upper right (see figure 2-4).
- (32) Press MENU. The top level menu appears. Position the cursor at FREQUENCY and press MARK.

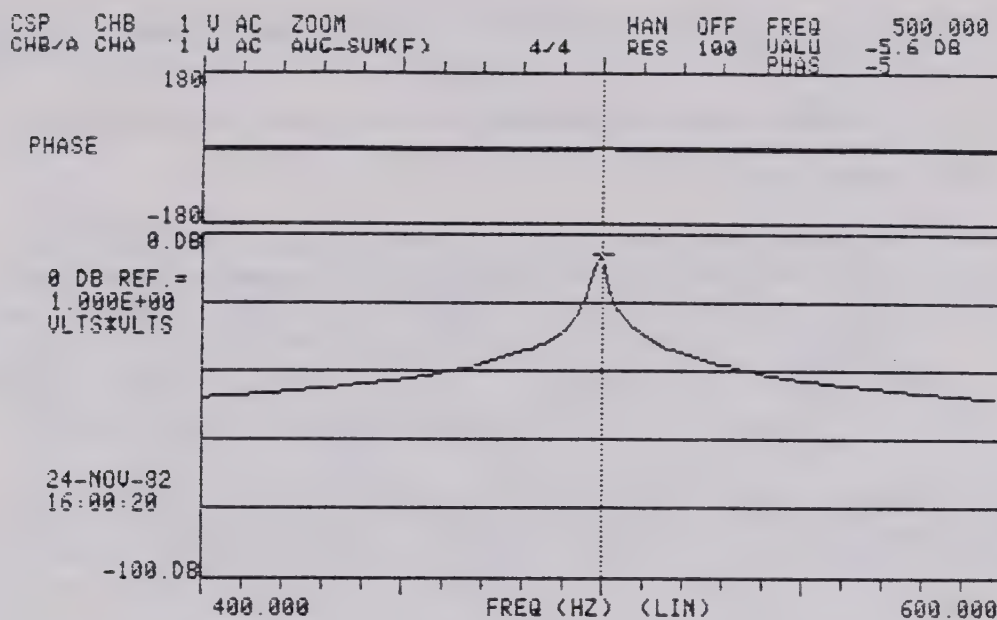


Figure 2-4. Typical Zoom Display

- (33) Position the cursor at BASEBAND and press MARK.
- (34) When the next menu appears, position the cursor at 10 kHz and press MARK. The resolution menu appears.
- (35) Position the cursor at 100 and press MARK. The top level menu appears.
- (36) Position the cursor at FUNCTION and press MARK.
- (37) Position the cursor at CROSS CORR and press MARK.
- (38) In the next two menus; position the cursor at B for the response channel and press MARK. Then position the cursor at A for the reference channel and press MARK.
- (39) When the top level menu reappears, position the cursor at AVERAGING and press MARK.
- (40) Position the cursor at SUM (summation averaging) and press MARK.
- (41) Position the cursor at 32 and press MARK.
- (42) Position the cursor at DONE and press MARK.

- (43) Press the SAMPLE DATA key. The display is replaced by a display of the input signal.
- (44) If necessary, adjust the oscillator for a sine wave at about 500 hertz.
- (45) Press START.
- (46) Watch the frame counter in the annotation above the grid. When it reaches ≈ 20 , press the STOP key. A new display will be produced (see figure 2-5).

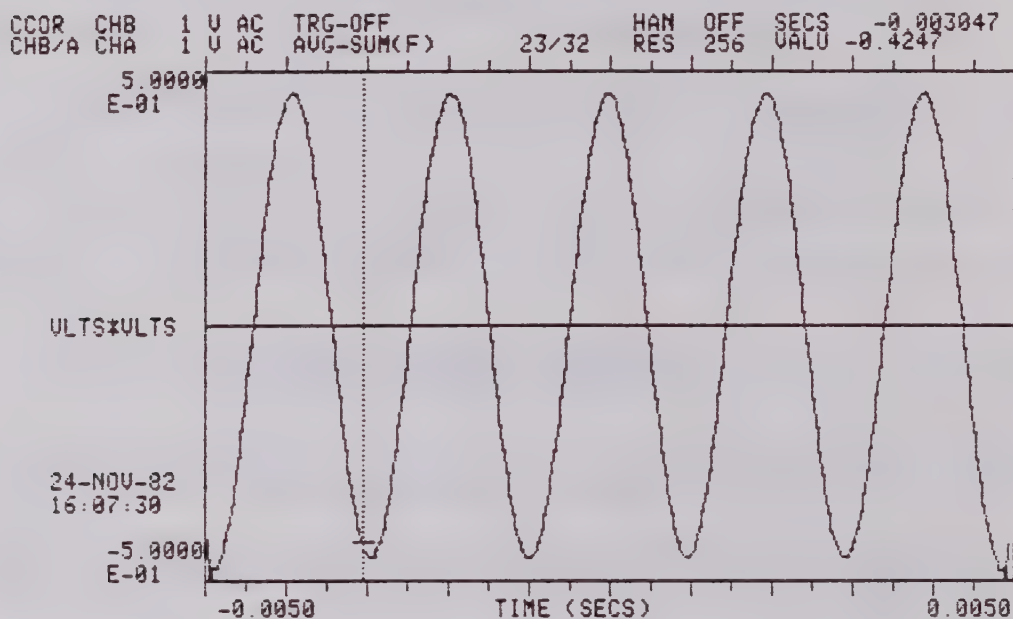


Figure 2-5. Cross Correlation Display

- (47) Press the RESUME key. Note that processing begins from the point at which it left off and continues until the 32 frames specified have been averaged, and then the results are displayed (see figure 2-5).
- (48) Press the MENU key to recall the menu to the display screen for further modifications.

This completes the demonstration procedure.

SECTION III

OPERATION

3.1 INTRODUCTION

This section provides a description of each of ISAP's ten sub-programs (Function, Frequency, Sensitivity, Trigger, Averaging, Windowing, Eng Units, Modal, Output, Disk I/O), the Exit command, the Display Format and Processing.

3.2 MENU-FORMAT PARAMETER SETUP

The MENU key may be pressed at any time to enter the setup process. Pressing the DISPLAY keys or the AVERAGING/START or RESUME keys to begin another function will exit the menu mode. When the menu selection process is initiated, the system prints the top-level menu shown below at the left of the data display:

```
MODIFY  
>FUNCTION  
  FREQUENCY  
  SENSITIVITY  
  TRIGGER  
  DISPLAY  
  AVERAGING  
  WINDOWING  
  ENG UNITS  
  MODAL OUTPUT  
  DISK I/O  
  EXIT
```

These menu items represent the basic functional areas which may be selected for modification. Within each area, the program sequences through all the parameters associated with the group, presenting an appropriate series of menus which allow the operator to select the desired value for each parameter. As each menu appears on the screen, a pointing cursor (>) appears at the left of the particular parameter which is currently in effect. To select another parameter, the cursor is moved up or down by tapping the ↑ and ↓ keys to position it at the desired choice. To enter the change into memory, and advance the program to the next sequential parameter menu, press the MARK key. The annotation on the screen will change to reflect modified parameters. Each time a selection is made, the program examines all parameters currently in effect and if any are not compatible with the newly entered parameter, the program will change the earlier, illegal parameter to one which is allowable. For example, if the function selected was one in which zoom processing is not available and later in the setup the operator chooses zoom mode, the program will automatically change the function to SPECTRUM with which zoom is compatible. The system automatically returns to the top level menu after sequencing through an entire menu series. To return to the top level menu at any other point in the setup process, press the MENU key.

3.2.1 Function Menu

When function is selected for modification, the following menu is printed:

```
FUNCTION
>SPECTRUM
  XFER FNCTN
  CROSS CORR
  AUTO CORR
  AMPL PROB
  WAVE AVG
```

These functions are defined as follow:

SPECTRUM. Four different single channel spectral functions may be plotted. The functions are defined by their y-axis units (chosen under the display menu):

Amplitude spectrum	Units X
Power spectrum	Units X ²
Power spectral density (PSD) (PSD = Power Spectrum/Bandwidth)	Units X ² /Hz
Energy Density	Units X ² -sec/Hz

The overall RMS level for the frequency range displayed, always expressed in Units X, is printed at the left for all the above.

XFER FNCTN. The transfer function requires two input signals. Coherence, frequency response (BODE), cross spectrum, impulse response, and co-quad display parameters are selected with the DISPLAY menu series. They may also be selected as noted at the end of Table 2-1.

CROSS CORR. The cross correlation function computes the similarity of two discrete signals as a function of the time lag between the two. Two input signals are required for this function.

AUTO CORR. Auto correlation is the comparison of a particular signal to the same signal after a time shift as a function of the time lag between the two.

AMPL PROB. The amplitude probability function plots are histograms giving the fraction of time in which an instantaneous amplitude occurs at the indicated level.

WAVE AVG. Waveform averaging or summation analysis, usually performed with triggering is the process of averaging successive waveforms to distinguish one type of signal from another.

After the FUNCTION has been selected, the system prints the following, if a single-channel function was selected:

```
CHANNELS
>A
B
C      } (if four channels are available)
D
AB
ABCD   (if four channels are available)
```

If a two channel function was specified (transfer function or cross correlation), the system asks for entry of a response channel:

```
RESPONSE CHAN
A
B
C      } (if four channels are available)
D
ALL
```

If four channels are available, the ALL option allows for the generation of three cross-channel FUNCTIONS simultaneously. For example, if the reference channel is A and ALL is specified for the response channel, cross-channel FUNCTIONS may be computed for B/A, C/A and D/A. Note that this four channel processing consumes considerable memory and some time, and may require smaller frame sizes, lower sampling rates or overlap factors in some cases. After the response channel has been selected for a two channel function, the selection of a reference channel is requested. The reference channel is not permitted to be the same as the response channel. Single-channel functions may be performed on any one channel, on two channels (A and B) simultaneously, or on all four channels simultaneously. Two-channel functions may be performed on channels A and B of a 2-channel system or on any two channels of a 4-channel system. If channels C or D are selected, data will be acquired on all four channels. If four channels are available, 2-channel functions can be performed with one channel as the reference and the other three channels as responses. The selection of the function and channels will cause the resolution to automatically decrease, if sufficient memory is not available for the function as requested. After the selection of the channel(s), the program returns to the top level menu.

3.2.2 Frequency Menu

When frequency is chosen for modification and transfer function or spectrum data has been selected, the following menu is printed. Other functions require baseband sampling and some proceed directly to that menu.

```
FREQUENCY
>BASEBAND
ZOOM
OVERLAP
```

The operator chooses the standard (baseband) analysis, or (if the system contains zoom hardware) an expanded display at a range to be specified, or overlap baseband processing.

BASEBAND. If baseband (normal) frequency is selected, the system lists the following available frequencies:

```

FREQUENCY
  10 Hz
  20 Hz
  50 Hz
 100 Hz
 200 Hz
 500 Hz
   1 kHz
   2 kHz
>   5 kHz
  10 kHz
  25 kHz
USER INPUT

```

USER INPUT. If user input is selected, the following menu will appear:

```

FREQUENCY
> 5000 Hz
DONE

```

To change the current frequency under user input:

- (1) Press MARK. The current value will be erased and the program will enter an alphanumeric entry mode. Note that when in this state, the menu selection cursor (➤) is gone and the RT-11 underline cursor (⎵) appears.
- (2) Type the desired value.
- (3) Press RETURN. The value entered is adjusted to the nearest valid frequency and displayed. Valid frequencies include the numbers 1 through 25 multiplied by 10, 100, or 1000.
- (4) Move the cursor to DONE and press MARK to advance to the next menu.

The frequency, and therefore the time frame length, may also be changed during the SAMPLE DATA or INPUT SPECTRUM Modes using the left (←) and right (→) arrow keys. If four channels are active, the 25 kHz range is not available for older analog-to-digital (ADS) (pre-December 1980) since the maximum sampling rate of the system would be exceeded. The sampling rate is set at 2.56 times the desired frequency range. The program sets the system's anti-aliasing filters to the frequency range selected.

After the desired frequency is selected, the program asks for processing resolution in terms of the number of spectral lines computed. For example:

```
#OF LINES
> 100
  200
  400
  800
 1600
 3200
```

The frequency lines available yield sampled data frame sizes of 256 through 4096 points, with 25/32 of the spectral lines computed being used, for the frequency domain functions auto spectrum, cross spectrum, frequency response, and coherence function. Waveform averaging and correlation functions contain 2.56 times as many displayable points as the specified number of lines. The impulse response functions contain 1.28 times the specified number of points. The number of lines available for a given function is computed by the program on the basis of the number of channels requested, memory availability, the averaging domain chosen, and the processing requirements. The MENU will list only those options which are possible. Hence, the 3200 line option will appear only for one or two channel baseband spectra on 64K systems. Two channel transfer functions of 1600 lines are possible for 64K systems, 400 lines for 32K systems. After selection of the resolution, the program returns to the top level menu.

ZOOM. If zoom processing for analysis of the data over a particular frequency range is desired and the system contains the appropriate hardware, this feature may be selected. The program will print:

```
EXPANSION
>DIS. EXPAND
  CF 1000.000
  BW  200.000
  LOF 900.000
  HIF 1100.000
  DONE
```

where DIS. EXPAND selects the frequency range last used for a display expand (see paragraph 3.4 for description of the expanded display feature), CF refers to center frequency, BW is bandwidth, LOF is low frequency, and HIF is high frequency. Any or all of these may be altered by the operator; however, these parameters are interrelated, after any one is changed the system recomputes the other affected values. If CF and/or BW are modified the system will recompute LOF and HIF. If LOF and/or HIF are changed the system will enter new values for CF and BW. To change a numerical parameter, perform the following steps:

- (1) Move the cursor to the parameter to be changed.
- (2) Press MARK. The current value will be erased and the program will enter the alphanumeric entry mode.
- (3) Type the desired value.
- (4) Press RETURN. The new value is entered in memory, the menu selection cursor reappears, and the system recomputes the affected values.
- (5) If another modification is to be made, repeat steps (1) through (4).
- (6) When finished, move the cursor to DONE and press MARK to advance to the next menu.

NOTE: ZOOM is available only for SPECTRUM or XFER FNCTN functions. ZOOM processing is limited by the number of channels selected for the function. The maximum allowable frequency for a single channel function is 7 kHz, for a two channel function 3 kHz, and 1.5 kHz for a four channel function. ZOOM data displays may also be expanded as described in paragraph 3.4.

The next menu asks for resolution as shown below. Refer to the description of resolution given for the normal frequency ranges above, and note that with ZOOM processing the spectral lines available are half that available for the normal ranges. The resolution options listed will be determined on the basis of memory availability, as above.

```
#OF LINES
> 50
  100
  200
  400
  800
```

After selection of the resolution has been made, the program returns to the top level menu.

OVERLAP. If overlap processing is selected, the frequency and resolution menus appear as for the BASEBAND option above, followed by an additional menu—Overlap Factor:

```
OVERLAP FACTOR
> 2
  4
  8
 16
```

The overlap factors available are a function of the frame size. For 400 line spectra the maximum factor is four; for 800 line, eight; etc. The overlap factor determines the number of frames which will be output (displayed or included in the overlap) for each input frame. This implies redundant processing of data. For example, if an overlap factor of four is specified, the first frame input will be displayed or added to the average, but successive output frames will consist of 1/4 frame of new data and 3/4 frame of (the most recent) old, already processed data. The advantages of overlap processing are twofold. For instantaneous spectra, an updated display may be presented more rapidly for low frequency data. Overlapping also has a smoothing effect, especially when the frequency of the spectral component is varying rapidly. To maximize the bandwidth available with overlap, which will be a function of processor speed, number of channels and frame size, no restriction is made on overlap factor-bandwidth selections. If a selection is made which cannot be accommodated (i.e., the data cannot be processed quickly enough), the data acquisition will terminate with the message 'DISCONTINUOUS SAMPLING'. The number of averages will be automatically increased if it is less than the selected overlap factor. After selection of the overlap factor has been made, the program will return to the top level menu.

3.2.3 Sensitivity Menu

The analog-to-digital converter subsystem (ADS) is programmable in eight full scale ranges (sensitivity) from ± 1.25 to ± 16 volts. The user has the option of selecting a specific range for an analysis or selecting autoranging (described below). If a selected range is too low, or if the input to the ADS is greater than ± 10 volts, the input data will be clipped by the hardware. If the selected range is excessively high, only a fraction of the resolution available to the ADS will be used resulting in undesirable effects such as low signal-to-noise ratio, low dynamic range and high quantization noise.

The first menu to appear when the sensitivity menu is selected is for autoranging:

```
AUTORANGE
> OFF
  ON
```

If ON is selected, the MAX VOLTS menu is skipped because it will be set automatically for each active channel. The next menu will ask for the lowest peak voltage level allowable during autoranging. This will be entered as a percentage of the maximum voltage.

```
LOWER LEVEL
  0 % MAX VLTS
> DONE
```

This menu is changed in the same manner as the USER INPUT values in the FREQUENCY menu. This lower limit is restricted to the 0% to 80% range. Whereas approximately 30% of the maximum voltage is desirable so not to significantly reduce the signal to noise ratio, too high of a lower limit may be too restrictive for autoranging. Autoranging is done only during the SAMPLE DATA or INPUT SPECTRUM modes (not during averaging) for all of the active channels. The selected value is also applied if HIGH/LOW is on (chosen in the DATA REJECT menu).

If autoranging is ON and the absolute value of the sample data is greater than the full scale value, the full scale value is increased. If the maximum data value is less than the specified LOWER LEVEL, the full-scale value is decreased. Any sample data which is outside the full-scale range is clipped by the hardware.

The next menu lists the available channels:

```
CHANNELS
>A
B
C      ) (if four channels available)
D      )
DONE
```

After selection of a channel is made, the system asks for maximum full scale value expected as shown below. The selection depends on the sensitivity of the signal conditioning equipment of the operators installation. If the input signal exceeds the maximum voltage selected an error message of 'ADS OVERLOAD' will appear during acquisition and the data may be corrupted.

```
MAX VOLTS DB
16          +24
8           +18
> 4         +12
2           +6
1           0
.5          -6
.25         -12
.125        -18
```

The system next asks for the input signal coupling of the channel of interest:

```
COUPLING
>AC
DC
```

The program now returns to CHANNELS menu above so specifications for another channel may be entered. To return to the top level menu, select DONE.

Whenever SAMPLE DATA or INPUT SPCTRM is selected for display, the sensitivity setting of the channel being displayed may be increased by striking the ↑ key, and decreased by striking the ↓ key.

3.2.4 Trigger Menu

The triggering menu is as shown below:

```
TRIGGER
>OFF
AUTO
MANUAL
```

The following conditions for triggering are available:

OFF. Default condition is no triggering. Data will be acquired in free run. Pressing MARK while pointer is at OFF returns the program to the top level menu.

AUTO. The system will automatically acquire every frame of data when triggering conditions are satisfied.

MANUAL. The system will wait for the operator to press the ARM TRIG key before recognizing the trigger conditions in each frame.

NOTE: When the message ARM TRIG appears on the screen, the ARM TRIG key (8) is the only input which will begin data acquisition.

The system next asks the operator to specify triggering source:

```
SOURCE
>CH A
  CH B
  CH C   (if four channel system)
  EXT ANALOG
  EXT DIGITAL
```

The choices are input channel A, B, or C (if available), an external analog signal, or an external digital signal. Connections for external triggering are made through BNC-type connectors at the back of the system's ADS unit (ADS EXT TRIG for analog, ADS DIG TRIG for digital). The digital triggering is on the negative-going slope, high to low level or contact closure. The next menu in the trigger series is used to specify the percent of + or - peak full scale, as set by the sensitivity specified, for triggering to occur. A response of 0 selects the zero crossing. (If an external digital source is used, the system skips this step.)

```
LEVEL
+FS
+80%
+60%
+40%
+20%
+10%
+ 5%
> 0%
- 5%
-10%
-20%
-40%
-60%
-80%
-FS
```

NOTE: The maximum range for EXT ANALOG input is ± 2 V. If EXT ANALOG is selected, these percentages are relative to that ± 2 V range, and do not depend on sensitivity setting. (For systems shipped prior to June 1981, the fixed EXT ANALOG trigger range is ± 10 V.) Also note that the EXT ANALOG does not trigger at the zero crossing (0%) if the triggering signal never crosses from positive to negative or vice versa (e.g., impact hammer impulse).

After level selection, the operator must specify whether triggering should occur on the positive-going slope, the negative-going slope, or during either (this menu is skipped if an external digital source is used):

```
SLOPE
>POSITIVE
  NEGATIVE
  EITHER
```

The system now asks for the number of frames of delay of the trigger event relative to the start of the data frame:

```
DELAY(FRAME)
>0%
  DONE
```

The acceptable range for trigger delay is -200% to 100% of the frame size. Positive values enable the display of up to one frame of data before the trigger. Negative values enable the display of up to two frames after the trigger. The trigger mode series of menus is now completed and the system returns to the top level menu.

NOTE: If triggering is specified, and no trigger occurs during either instantaneous or averaged data acquisition, the operator may force acquisition by hitting any key. Program control will return to the operator after one frame of data has been acquired (there will be a delay for low sampling frequencies and/or high resolution). Also, if ZOOM or OVERLAP processing has been requested, the triggering will apply only to the first frame of input. Triggering for subsequent frames would cause discontinuous input resulting in processing errors.

3.2.5 Display Menu

The first menu to appear under DISPLAY is used to select either the INSTANTANEOUS DISPLAY mode or the AVERAGED DISPLAY mode. This menu appears as follows:

```
SET UP
>INSTANT
  AVERAGED
  DONE
```

3.2.5.1 Instantaneous Display. The first menu to appear under INSTANT is used to select the DISPLAY FORMAT. This menu appears as follows:

```
DISP FORMAT
  NONE
>1-CHANNEL
  2-CHANNEL
  4-CHANNEL
```

The 1-channel, 2-channel, 4-channel or NONE options under the DISP FORMAT Menu allow the user to inspect data and/or spectra from up to four input channels at a time. If the 1, 2, or 4 channel option is selected, the appropriate input channel(s) is displayed during averaging, and each frame of data is displayed before it is processed. If the NONE option is selected, the input from channel 1 (A) is displayed while in the SAMPLE DATA or INPUT SPECTRUM modes, but no data is displayed during averaging. In certain cases (such as OVERLAP sampling) it may be necessary to select NONE to avoid the "DISCONTINUOUS SAMPLING" message. The next menu to appear is used to select the TIME DATA plot mode. This menu appears as follows:

```
TIME DATA
>POINT MODE
LINE MODE
```

After a selection is made in the TIME DATA menu the program returns to the DISPLAY SETUP menu.

3.2.5.2 Averaged Display. When the AVERAGED DISPLAY parameters area is selected for modification, the first menu appearing will depend upon the function which is selected.

DISPLAY Menu for SPECTRUM Function. If the SPECTRUM function has been selected, the display menu series is as follows. If multiple channels have been selected, the first menu to print out is a request for the channel to be displayed for processed data:

```
CHANNEL
>A
B
C      )
D      ) (if four channels are available)
```

If TIME domain averaging has been selected in the AVERAGING setup menu, you are given the option of displaying either the averaged input WAVEform or the Power Spectral Density (PSD).

```
DISPLAY
>PSD
WAVE
```

For FREQUENCY domain averaging, only PSD is available for display. If WAVE display is selected, the vertical scale will be forced to LINEAR, in units of X, and the following UNITS and log SCALE menu selections are irrelevant.

NOTE: If TIME domain AVERAGING was selected and a processed AVG display is being presented, the display can be switched from the FREQ domain PSD to the TIME domain WAVEform average without returning to the DISPLAY menu by striking the A, B, C, or D key for the frequency spectrum of the corresponding channel, and then striking the W key for the waveform average of the same channel.

The next menu requests the units for the vertical scale as follows:

```

UNITS
>X**2
  X**2/HZ
  X**2-SEC/HZ
  X

```

The X represents the engineering units chosen by the operator for calibration (volts, if ENG UNITS has not been activated). X**2 is units squared if a single-channel function or units times units if a CROSS SPEC function (see paragraph 3.3.5.2). The X**2 scale is a power scale commonly used for deterministic signals (power spectra). X**2/Hz is the power spectral density scale, most appropriate for noise-like signals. X**2-Sec/Hz is the energy density scale. The X scale indicates RMS amplitude of the input components. The next menu requests the vertical scaling units as follows:

```

SCALE
>100 DB
  80 DB
  60 DB
  40 DB
  20 DB
  LINEAR

```

The vertical scale may be logarithmic, log-dB, or linear. For logarithmic and log-dB displays, a choice of the 20, 40, 60, 80, or 100 dB display ranges is available. If one of the log ranges was selected, the following menu will appear.

```

LOG SCALING
>LOG
  DB

```

The LOG choice will result in a display with logarithmic scaling, but with engineering unit labels for the min and max scale values. DB scaling is also logarithmic, but with dB labeling with respect to a dB reference. DB scaling will be 20 Log X for frequency response functions and spectra with units X, 10 Log X for all other functions. The next menu requests the type of scaling as follows:

```

SCALING
  FIXED
>AUTO

```

T - Transfer Function
 G - Coherence
 X - Cross Spectrum
 I - Impulse
 Q - CoQuad
 W - Wave (for TIME averaging only).

To change the response channel, simply press the key (A, B, C, D) which corresponds to the menu, the auto spectrum for that channel will be displayed. Then press the key (T, G, X, I, Q, W) which corresponds to the desired function.

DISPLAY Menu for CROSS CORR Function. When CROSS CORR (cross correlation) is the function which has been selected, the display will be in the time domain and will require two inputs. The only menu in the DISPLAY series which is applicable is the vertical SCALE (fixed, auto) menu. After this selection the program returns to the top of the menu.

DISPLAY Menu for AUTO CORR Function. If AUTO CORR (auto correlation) function was selected, only the selection of the vertical SCALE will be required, except that if 2 or 4 input channels were selected the program will first present the CHANNEL menu here so the operator may specify a single channel.

DISPLAY Menu for AMPL PROB or WAVE AVG Function. If either AMPL PROB (amplitude probability density) or WAVE AVG (waveform averaging) were selected, the CHANNEL menu will be the first to appear (if required) in the DISPLAY series, followed by the vertical SCALE (fixed, auto) menu and then a return to the top level menu.

3.2.6 Averaging Menu

The Averaging menus allows selection of averaging in either the time or frequency domain, the averaging mode (summation or exponential), the number of averages, and input data rejection algorithms are discussed below.

3.2.6.1 Domain Menu

If a frequency domain function (i.e., SPECTRUM or XFER FNCTN) has been selected in the FUNCTION menu, the program provides the choice of averaging in the FREQUENCY domain or the TIME domain with the following menu:

```

DOMAIN
>FREQ
TIME
  
```

The FREQ domain averages the power psectrums of the individual input frames. In TIME domain, the sampled data is averaged and then the spectrum of the averaged data is calculated. When TIME averaging is selected, both the spectrum result and the waveform average are available for display as described in the DISPLAY menus. If TIME averaging is selected, the EXponential decay mode is not applicable, and the following menu will indicate only SUM. This averaging DOMAIN menu does not appear for the time domain functions CORrelation or AMPL PROB, nor for WAVE AVG which are time domain averaging by definition.

3.2.6.2 Average Mode Menu

The default average mode is summation average. When the averaging mode is to be changed, the setup menu reads:

```
AVG MODE
>SUM
EXP
```

SUM. Averaging will be performed in the summation mode. This provides a straight arithmetic averaged.

EXP. Weighting based on exponential decay of past frames (most recent frames given most importance) will be used in the averaging process. The number of frames is used as the discount factor for the averaging of the data according to the equation:

$$By(k) = (1 - 1/\text{discount})By(k) + (1/\text{discount}) Bx(k)$$

where $By(k)$ is the averaged sum of all past frames and $Bx(k)$ is the current frame. In this mode averages are taken continually until the stop key is pressed but the display will be updated at each multiple of the frame count.

3.2.6.3 Number of Averages Menu

The system next asks for the number of averages to be performed during processing:

```
# OF AVGS
1
2
> 4
8
16
32
64
128
256
512
1024
```

NOTE: A minimum of 2 averages is required for exponential averaging.

3.2.6.4 Data Reject Menu

The Data Reject menu allows selection of several choices as shown below:

```
DATA REJECT
OFF MANUAL
OFF HIGH/LOW
OFF DBL HIT
> DONE
```

MANUAL. As each frame of data is taken during averaging, the message HIT X TO REJECT will appear and the program will wait for operator input. The current frame of data will not be included in the average if the X key is pressed. Any other key will cause the data to be accepted. "ACCEPTED-USER" or "REJECTED-USER" will appear according to the keyboard input.

HIGH/LOW. Each frame of data during averaging is tested for an overload or a low maximum value. If the data is too high or too low, the data is rejected and a "REJECTED - TOO LOW" or a "REJECTED - TOO HIGH" message will be given. The lower limit is specified by the operator (refer to paragraph 3.2.3) as a percentage of the maximum voltage.

DOUBLE HIT. Only XFER is chosen under FUNCTION and the sampling is triggered, the reference channel input during averaging will be tested for a double hit. This is intended to be used for impact hammer testing where a double hit will contaminate the processed data. This option may be shown as being ON but will only be applied for triggered transfer functions.

The data values after the impulse peak are compared to 5% of the peak's maximum value. If this data is higher than 5%, the sample is rejected and a "REJECTED - DBL HIT" message is given.

To change the desired options under the Data Reject menu from ON to OFF or from OFF to ON:

- (1) Move the cursor to the option.
- (2) Press MARK. The option will indicate ON if it was OFF or it will be OFF if it was ON.
- (3) Continue steps 1 and 2 until the Data Reject menu is set up as desired.
- (4) Move the cursor to DONE and press MARK.

If HIGH/LOW is ON, the following menu will appear for the selection of the lower voltage level:

```

LOWER LEVEL
>0% MAX VLT
DONE

```

This is the same menu and value used to set the lower limit for AUTORANGE.

NOTE: These data reject options do not function under ZOOM and will cause a "DISCONTINUOUS SAMPLING" message for certain conditions under OVERLAP sampling. Also, 1-, 2-, or 4-Channel must be selected under the DISP FORMAT menu if the data reject options are to be used.

After DONE is selected, the program returns to the top level menu. (Note that a minimum of two averages is required for exponential averaging.)

3.2.7 Windowing Menu

The first menu to appear is for the Hanning window. The menu reads as follows:

```
HANNING
>AUTO
  OFF
  ON
```

AUTO. Hanning weighting will be applied by the system as appropriate when in automatic mode. It will be on when free-run acquisition and a frequency domain function (SPEC or XFER FNCTN) are selected, and off for all other conditions.

OFF. This selection holds Hanning off for all acquisition conditions regardless of triggering.

ON. This selection holds Hanning on for frequency domain and correlation functions regardless of triggering conditions.

The operator may choose to apply Hanning input weighting function during signal processing, to omit it, or to allow the system to determine when it should be used for smoothing the computed spectrum. Hanning weighting of a function reduces the maximum (volts squared) spectral amplitude. Hanning weighting is a standard procedure when working with broad band measurements, because the reduction in overall amplitude is not apparent during analysis. However, in the analysis of a narrow band or deterministic signal (such as a sine wave) the amplitude reduction is apparent and COMP should be selected. If Hanning weighting is in effect, either through the selection of 'ON' or 'AUTO' without triggering the following menu will appear:

```
SCALING
>COMP
  NO COMP
```

COMP. This selection enables a correction factor of $\sqrt{8/3}$ to restore the amplitude of either a narrow band or deterministic signal to its un-Hanned value when Hanning is selected.

NO COMP. Normal Hanning weighting for broadband signals.

If XFER was chosen under FUNCTION and the trigger mode is not OFF, the following menu will appear:

```
IMPACT WINDOW
>OFF
  ON
```

Impact windowing is used for impact hammer testing. A force window is applied to the data from the reference channel and an exponential window is applied to the data from the response channel(s). The force window is applied as follows: the data remains unchanged until after the impulse signal level has dropped to about 10% of its peak value; a half-cosine window (from 1 to 0) is applied to the next 1/16 of the frame, and the rest of the data is set to zero. This has the effect of eliminating unwanted bit noise after the impulse. The exponential window is applied to the response data frame(s) as an exponential curve beginning at the start of the frame. This window is applied a number of times as indicated by the operator. This has the same effect as increasing the damping and causes the response signal to die out faster. It is desirable to have the signal near zero at the end of the time frame to avoid aliasing. The formula for this window is as follows:

$$X(n)=X(n)*W(n)$$

$$W(n)=(1-0.0002*K*1024/framesize)**n$$

where n is the index from the start of the frame (0.. framesize-1);
 $X(n)$ is the time domain function, $W(n)$ is the window function;
 K is the number of times the window is applied;
 Framesize is time domain data size, i.e., 512, 1024, 2048...;
 1024 is for fixed size in SDRC's MODAL analysis, so the ISAP is compatible with SDRC's MODAL in any framesize.

If IMPACT WINDOWING is selected as ON, the following menu will appear for the selection of the number of times the exponential window will be applied.

```
EXPON.WINDOW
>0 TIMES
DONE
```

Each application of the window increases the apparent damping of the response signal so that the effects of noise after the impulse are reduced. This has a smoothing effect on the trace of the frequency response function and does not affect the values of the resonance frequencies. However, this increased damping may cause closely spaced resonance peaks to become more difficult to distinguish.

To enter a new value:

- (1) Press MARK. The previous value is erased and the program enters the alphanumeric entry mode.
- (2) Enter the desired value (0 to 20) and press RETURN.
- (3) Move the cursor to DONE and press MARK.

After selection, the program returns to the top level menu.

The following parameter selections are suggested to insure accuracy in impact tests when IMPACT WINDOWING is used:

SENSITIVITY:	Use ac coupling on all active channels to null dc bias.
TRIGGER:	The trigger delay must not be less than 0% nor greater than 40%. If exponential windowing is selected, the trigger delay should be kept to a minimum since the window starts at the beginning of the frame.
DISPLAY:	Select 1-, 2-, or 4-CHANNEL under the DISP FORMAT menu. The windowing will not work if NONE is selected.
EXPON WINDOW:	The number of times that the exponential window is applied (N TIMES) should be the same for all points on the structure. Inconsistencies may lead to inaccurate results in a subsequent MODAL analysis.

During the display of time data, the Windowed data may be viewed by hitting the "W" key. If windowed time data is being displayed, an asterisk (*) will appear at the top of the screen next to the number of exponential window applications. The non-windowed display may be restored for subsequent frames by hitting the "W" key again.

3.2.8 Eng Units Menu

Each channel in use can be calibrated in volts or in an operator-specified unit such as g's. These physical units then become attached to the data for each channel and are used to calibrate, scale, and label all displays. The default condition is OFF (calibration will be in volts). To change the physical units, select ON in the menu below (if OFF is selected, the program returns to the top level menu).

```
ENG UNITS
ON
>OFF
```

When ON is selected, the program asks for the channel of interest:

```
CHANNELS
>A
B
C      )
D      ) (if available)
DONE
```

After the channel has been selected, the following menu appears:

```

ENG UNITS
> ARE "VLTS"
  1.000 /V
  or 0.00 dB
  @ 1.000 V
NEXT CHAN

```

Calibration may be specified in either of two ways: The operator may specify a scale factor in terms of the number of physical units per volt or he may specify the number of dB above or below one physical unit represented by a given voltage level. If the operator changes the number of units per volt, the system will recompute the dB equivalent, and if the operator changes the dB value or dB reference voltage, the system recomputes the units per volt. As in the zoom parameter setup, pressing the MARK key in this menu puts the system into an alphanumeric entry mode; the menu cursor (>) is gone and the RT-11 underline cursor () appears. To change the calibration setup, perform the following steps:

- (1) Move the cursor to the parameter to be changed.
- (2) Press MARK. The current unit or value will be erased.
- (3) Make the desired entry. NOTE: Up to four characters may be typed within the quotation marks to represent physical units.
- (4) Press RETURN. The new unit or value is entered in memory and the system recomputes any affected values accordingly.
- (5) When finished, move the cursor to NEXT CHAN and press MARK to return the program to CHANNELS.
- (6) If another channel is to be calibrated, select it and repeat the procedure from step (1) through step (5). When all channels have been modified as desired, select DONE to return to the top level menu.

3.2.9 Disk I/O Menu

Parameter setups and data may be saved on or retrieved from disk. The user must select the appropriate read/write option, and then specify a file name. The term SETUP in the menu refers to the setup parameters only, while DATA implies the setup parameters plus the processed data. The menu appears as follows:

```

DISK I/O
> READ SETUP
  READ DATA
  STORE SETUP
  STORE DATA

```

After one of these options is selected the message "FILE NAME" appears. Enter the desired file name in the following form:

dev:name.ext(RETURN)

If the device code (dev:) is not specified, the default device (DK:) is assumed. If the extension (.ext) is not specified, the default extension (.DAT) is assumed, i.e., the entry of ABC(RETURN) is interpreted as DK:ABC.DAT.

Upon successful completion of the reading or writing operation, the main menu will reappear. Data read from a disk file can be viewed by pressing the DISPLAY/AVG key. Errors may occur if a nonexistent or invalid file is specified for reading, if there is not sufficient room on the disk for a write (STORE) file, or if the file name syntax is violated. It is permitted to read the setup only (using READ SETUP) from a file containing setup and data, i.e., one created using STORE DATA. However, an error will occur if an attempt is made to READ DATA from a file created using STORE SETUP. It is suggested that a convention such as filenames ending in S for SETUP files and filenames ending in D for DATA files be used to jog the memory and reduce the likelihood of this error. When STOREing, if the name of a file which already exists on the disk and contains previously recorded data and/or setups is specified, the contents of the file will be overwritten by the new material.

3.2.10 Modal Output

The MODAL OUTPUT function has been added to ISAP in version V03. It is provided for use in conjunction with MODAL and MODAL-PLUS structural analysis programs available from GenRad. Since MODAL OUTPUT is solely for that purpose, the following description assumes that the user is thoroughly familiar with the use and conventions of those MODAL programs.

NOTE: This MODAL OUTPUT function is not compatible with MODAL programs prior to version V06. The MODAL function file structure is changed from V05 to V06. A MODAL program file called NEWCOR is available to convert V05 and previous files to V06 format.

With the MODAL OUTPUT function, ISAP can write its transfer function results into MODAL-format Frequency Response Functions (FRF) files. These files are created under the MODAL Programs. The ISAP program can be used to perform the data acquisition and transfer function processing stages of a MODAL structural analysis project. This combination is advantageous because ISAP, in a single processing operation, can produce frequency response functions of much greater resolution than MODAL — up to 1600 lines baseband for ISAP (in systems with 64K memory) versus a fixed 512 lines (400 effective) for MODAL. This can reduce, and frequently eliminate, the need for additional "zoomed" functions required to give necessary resolution in a particular frequency range. This, in turn, significantly reduces the total time required in the data acquisition stage of a modal analysis project. ISAP writes these larger transfer function results into the fixed-length records of MODAL function files, using record sequence numbers 0,1,2, and 5, as required or those specified by the operator.

The frequency range information for each sequence number is carried in the record header. These additional records can be treated the same as zoomed functions in subsequent MODAL processing operations.

3.2.10.1 Operation

ISAP does not create MODAL-format Function files. That operation must be performed under MODAL during the general project file setup stage. Once the structure of such a MODAL file exists, ISAP can open it and write new transfer function results (i.e., MODAL FRFs) into it. Also, existing FRFs can be read and displayed, and unwanted functions can be deleted. ISAP can also list directories of the functions in the file, which are identified by their reference-response coordinate pairs in the standard MODAL format. These data-manipulation functions are selected from the MODAL OUTPUT menu as listed below, and are further described under the submenus for the individual operations:

```

MODAL OUTPUT
> SETUP      (to open an existing MODAL function file)
  WRITE      (to write ISAP transfer functions to the file)
  READ       (to read and display FRFs from the file)
  DELETE     (to delete unwanted FRFs from the file)
  DIRECTORY  (to list the contents of the file by ref-resp coordinates)
  DONE       (to exit MODAL OUTPUT and return to ISAP top level
              menu)

```

3.2.10.2 Setup Function

The setup function is used to open the existing MODAL Function files, and it allows entry of record identification labels as follows:

```

SETUP
> FN FILE
  FN LABEL
  DONE      (return to MODAL OUTPUT, WRITE function)

```

The program will request entry of the name of the MODAL Function file to be opened:

```

FILE NAME
*dev:filnam.typ(RETURN)

```

Device DK: and type .DAT are assumed if not given. A "File Not Found" message will be returned if the file does not already exist. Once the file is opened, it will remain open until you either CTRL/C or EXIT from ISAP to the system monitor, or use this SETUP function again to open another file. If desired, you may enter a record identification (i.e., FN LABEL) of up to 58 characters. This label will be associated with each of the function records written to the file. The label may be changed at any time in an output sequence by recalling SETUP. This entry does not affect the 58 character label identification that may be assigned to the file as a whole when it is created under MODAL.

3.2.10.3 Write Function

The write function menu provides for the assignment of a reference and response coordinate pair to the current processed transfer function. These coordinates and transfer functions are written to the file as described below. Note that the MODAL OUTPUT function operates only on XFER FNCTN data. An INVALID DATA message will appear if any other function is displayed when the write is attempted.

```
WRITE
> REF
  RESP
  SEQ
  STORE FN
  DONE
```

REF. Selecting REF replaces the menu pointer with the alphanumeric cursor for entry of a reference coordinate in the standard MODAL format of location number (1-8000), excitation axis (X, Y, or Z), and direction (+,-) for example:

13Y+ (RETURN) (if the direction (+,-) is not entered a "+" is assumed)

Remember, you must (MARK) the REF choice before entering the coordinate. If you do not, the first character entered may be taken as an ISAP special key command for a menu or processing operation.

NOTE: This REFERENCE coordinate entry will be reflected in the lower left corner of the display. It will remain in effect until it is specifically changed by a new REF entry. In the usual MODAL analysis data acquisition sequence, the same REF coordinate will be used for numerous transfer function operations with different RESPONSE coordinates. After the initial entry of a REF coordinate, merely striking the "M" key by itself will cause the program to return directly to the WRITE menu, with the pointer already positioned at the RESPONSE selection below. Thus, you need only to (MARK) and enter a new RESP coordinate for each subsequent STORE FN until you want to enter a new REF coordinate. Whereas REF can remain the same throughout an operating sequence, a new RESP coordinate entry is required before a new STORE FN execution is allowed.

RESP. When the alpha cursor appears, the response coordinate for the function to be written, e.g., 2Y-(RETURN). This entry will appear along with the REF at the lower left of the display, and both will remain there until specifically changed, as a reminder of the last REF/RESP pair that was used.

SEQ. The alpha cursor will appear and the operator may insert a sequence number (0-255) where the record is to begin. For functions with a resolution greater than 400 lines the additional records are stored in the files beginning at the specified sequence number and incremented by one until all of the data is recorded. This step may be skipped and a default of zero is assumed.

STORE FN. This command actually writes the current processed transfer function result into the file under the REF/RESP coordinate pair and sequence number entered above. Note that the MODAL OUTPUT function can be used to write only XFER FNCTN results, and that the current display must be a XFER FNCTN. An INVALID DATA message will appear if any other result is being displayed.

Baseband transfer functions up to 400 lines can be written into the 512-element record for the specified REF/RESP coordinate pair and sequence number indicated. Elements of the record beyond the valid data are cleared to zero. This zero area will show in subsequent displays under the MODAL Program, which normally displays all 512 elements of a record. For larger ISAP baseband transfer functions (800 or 1600 lines), the function will be written consecutively into MODAL sequence numbers beginning at 0 or the operator specified number as required, with the ISAP result partitioned and overlapped as shown by the line index numbers in the diagram below. The start frequency and frequency resolution information for each block are carried in the record headers, so that MODAL can treat each sequence number block as zoomed data in its subsequent calculations. For example, if the user specified sequence number 5, a 1600 line transfer function would be written into record numbers 5, 6, 7, and 8. If a sequence number is not assigned, a default of zero is assumed and the data will be written into record numbers 0, 1, 2, and 3.

3.2.10.4 Read Function

The read function provides for recall and display of transfer functions, as identified by REF RESP coordinate pairs, from the file. Operation with the following menu is essentially the same as for WRITE. However, note the conditions in the description below.

```

READ
> REF      (MARK) and enter the ref coordinate, e.g., 3Y-(CR)
  RESP     (MARK) and enter resp coordinate, e.g., 2Z+(CR)
  SEQ RNG  (MARK) and enter the range of sequence numbers, e.g., 2, 5,
           or 8 (CR)
  LOAD FN  (MARK) to load and display the specified function
  DONE     (MARK) to return to the MODAL OUTPUT menu

```

The REF/RESP coordinates entered above will be shown at the lower left of the display. However, upon exit from the READ function, they will again be replaced by the REF/RESP pair from the previous WRITE operation. The sequence range indicates which records under the selected REF/RESP are to be read. For single record function (functions of 400 lines or less) enter the number of the record to be read. For larger functions a range must be specified to include all applicable records. The number of the first record, a comma, and the number of the last record will read the range including end points, e.g., 5, 8 (would read a 1600 line function). The default is to read a single record at sequence zero. You must setup the desired DISPLAY conditions before executing the load FN step. Functions that are read from the file are loaded only into the display scratch area of memory. They can be censored but cannot be manipulated after they have been read in. Striking any key not related to cursoring will cancel the display and cause ISAP to revert to a sampled input display. The READ function can properly sort out and reassemble large transfer functions that occupy

more than one sequence number record as shown above. While the READ display is present, the display annotation will properly reflect all conditions that apply to the transfer function when it was written, except for input conditions, which will reflect the current local setup. Recording the setup conditions that exist at this time of acquisition into a setup file via a separate disk I/O procedure may be helpful to avoid confusion.

3.2.10.5 Delete Function

The delete function deletes transfer functions from the Function file, and makes the space available for new ones. Menu operation is basically the same as for WRITE and READ, with the function to be deleted indicated by the entry of its REF/RESP and sequence coordinates. Execution is commanded by the selection of >DELETE FN:

```
DELETE
>REF      (MARK) and enter coordinates, e.g., 3Y-(CR)
RESP      (MARK) and enter coordinates, e.g., 2Z+(CR)
SEQ RNG    (MARK) and enter range or single coordinate, e.g., 2, 5, or 8
           (CR)
DELETE FN  (MARK) to execute
DONE       (MARK) to return to MODAL OUTPUT menu
```

3.2.10.6 Directory

The directory function prints a list of the REF/RESP coordinate pairs and sequence numbers used for each transfer function that exist in the open file. For example:

```
MODAL FUNCTION NAME:  MODLDT
TOTAL # POSSIBLE:    18
```

REFERENCE	RESPONSE	SEQ #
9X+	2Y+	6
9X+	2Y+	5
9X+	2Y+	4
9X+	2Y+	3
20X+	33Y+	10
30Y+	30Z+	0
10Y+	20Z+	5
30Y+	1Z+	0
250X+	10X+	0
130Y+	44Y+	0

3.2.11 Exit

Selection of this menu option will cause the current parameter setup to be saved in the parameter default (ISAP.DEF) on the default device. The parameters in this file will automatically be loaded whenever the program is again entered from the monitor. After the parameters have been saved, the screen erases and the monitor prompt will appear, indicating readiness to accept RT-11 monitor commands.

3.3 DISPLAY FORMAT

Each display includes calibrated tick marks and annotations. Figures 3-1 through 3-3 shows typical displays and annotation for SAMPLED DATA (Figure 3-1), INPUT SPCTRM (Figure 3-2) and AVERAGED SPECTRUM (Figure 3-3). Pressing any of the keyboard DISPLAY keys causes the program to exit the menu setup routine and replace the previous display with the one selected. The SAMPLE DATA and INPUT SPCTRM keys may be used at any time (except during the averaging process) to view raw input data without invalidating any processed data which may already be in memory. The AVG key may be used at any time to view processed data. If no valid processed data exists, sampled data is displayed.

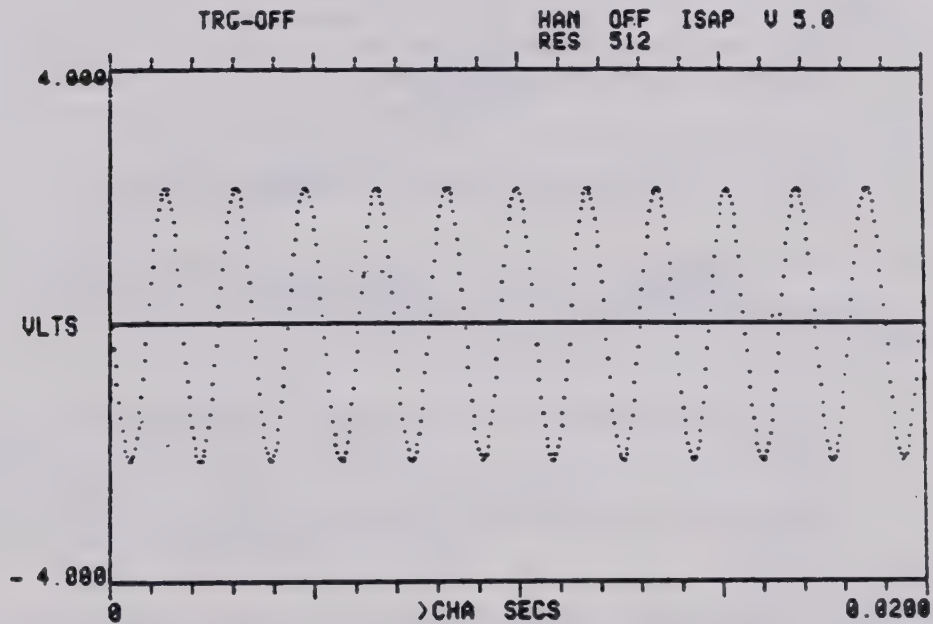


Figure 3-1. Typical Sampled Data Display and Annotation

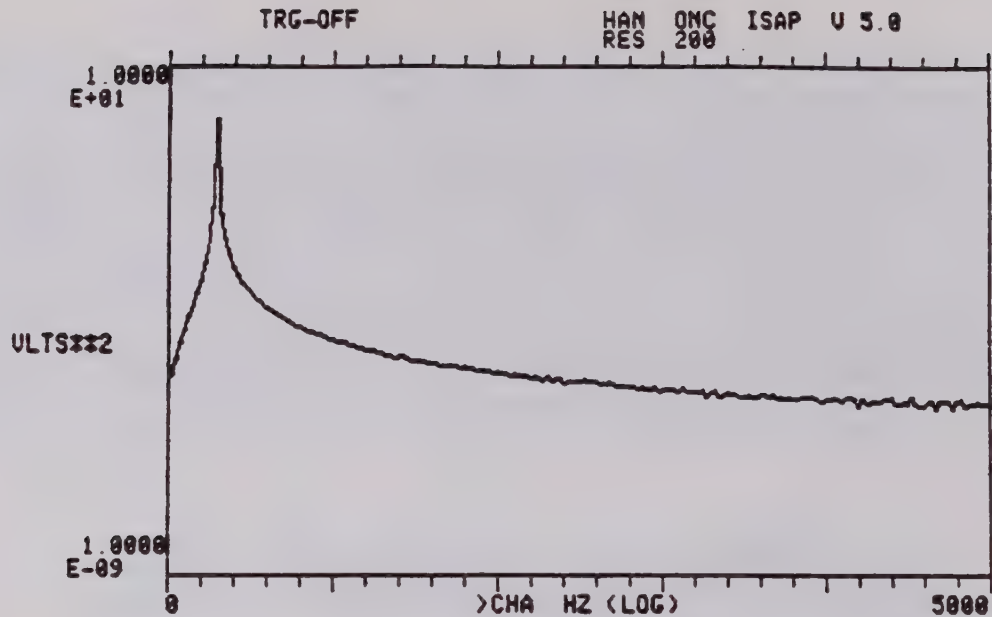


Figure 3-2. Typical Input Spectrum Display and Annotation

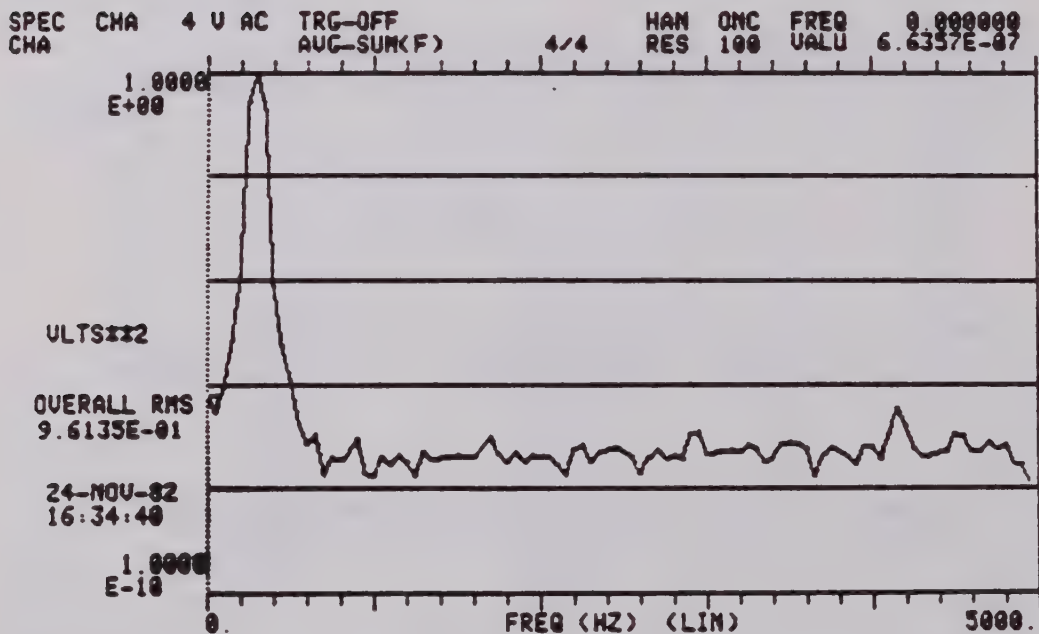


Figure 3-3. Typical Averaged Spectrum Display and Annotation

3.3.1 Display and Annotation

The annotation available for each display label includes the following information for the channel(s) being used:

Function	}	Averaged display
Channel(s)		
Sensitivity (in volts for each channel)	}	
Triggering mode		
Trigger source (channel or external)	}	If not ZOOM or OVERLAP sampling
Percent of full scale for triggering		
Slope (P=positive, N=negative, E=either)	}	
Percent frame delay		
Type of averaging (SUM or EXP)	}	
Domain where averaging is to be performed (Frequency or Time)		
Number of exponential windows applied (if triggered XFER and IMPACT window on)		
Current number of averages (continually updated during averaging)		
Total number of averages to be performed		
Hanning ON, OFF or ONC (compensated). Auto will select as appropriate.		
Resolution in numbers of spectral lines		
Program version number		
Error messages		
Data reject messages		
Display cursor position data (averaged display)		

The annotation around the display will also contain the following:

Vertical scale calibrated in engineering units chosen by user,
 Frequency or time horizontal scale,
 Overlap factor (OVERLAP processing),
 Overall RMS value (processed spectrum displays),
 Date and time of last averaged sample.

All displays of processed data have variable scaling. Linear scaling is available for all functions: spectral and the frequency response function may be logarithmically scaled. The processed data displays will either be autoscaled or scaled according to a fixed value specified by the operator. For complex quantities (cross spectrum or frequency response), displays are presented in a Bode plot format (magnitude and phase with phase being displayed above the magnitude with a range of -180 degrees to +180 degrees).

3.3.2 Sampled Data Display

A display of the currently sampled data is called to the screen by pressing the SAMPLE DATA key. The number of input channels that are displayed (1-4) is dependent on how the queries in the FUNCTION and DISPLAY menus were answered. If a channel was requested for display during the FUNCTION menu, and it is not displayed when the SAMPLE DATA Key is pressed, it may be called to the screen by pressing the key (A, B, C or D) associated with that channel. If impact windowing was selected, the windowed data may be viewed by hitting the "W" key. If the windowed data is being displayed an asterisk (*) will appear at the top of the screen after the number of window applications. The display of normal time data may be restored by hitting the "W" key again. The sampled data display is always of the selected channel(s) and is displayed in either a points mode with 512 sampled data points per frame during time domain or in a line mode with 200 lines per frame during frequency domain. Scaling for sampled data is fixed at the full scale value of the channel input attenuator and is expressed in either volts or engineering units as specified during the ENG UNITS menu. During the SAMPLE DATA mode (as well as the INPUT SPECTRUM mode) the user can modify the magnitude, sampling frequency and/or domain of the display(s), without returning to a menu. If multiple input channels are displayed when the SAMPLE DATA key is pressed, the user must identify which input channel display is to be modified by pressing the key associated with that channel (A, B, C, D). This will position the pointing (▷) cursor at that channel label.

Domain. To change the domain of the selected display, press the key (A,B,C,D) associated with the display a second time and the domain will change from time to frequency or vice versa.

Magnitude. To increase the sensitivity for the channel being displayed (decrease the maximum voltage) tap the up arrow (↑) key. To decrease the magnitude of the data being display (increase the maximum voltage) tap the down arrow (↓) key. These operations actually change the input attenuator value for that channel. If AUTORANGE is ON, this will be done automatically for all of the active channels until there are no 'ADS OVERLOAD' messages and the lower limit set by the user has been satisfied.

Sampling Frequency. To increase the sampling frequency, tap the left arrow (←) key. To decrease the sampling frequency tap the right arrow (→) key. Note that when the left or right arrow keys are tapped, the sampling frequency for ALL of the displays is changed.

NOTE: If the NONE option under the DISPLAY FORMAT in the DISPLAY menu is selected, the SAMPLE DATA (and INPUT SPECTRUM) mode will default to the 1-Channel Display Format.

3.3.3 Instantaneous Spectrum Display

Pressing the INPUT SPCTRM key results in a display of the spectra of a current frame of input data from the selected channel(s). These spectra will differ from displays of processed data in that they will always have a 200-line resolution and will be scaled according to the input channel sensitivity. They are continuously

updated while being displayed. The y-axis scaling may be linear or log, as specified for the current AVERAGED display in the DISPLAY menu. If an averaged function with linear default (e.g. amplitude histogram) has been selected, only linear scaling will be available for the instantaneous spectrum. The input attenuator, frequency and domain may be changed as described under SAMPLED DATA DISPLAY. If overlap processing has been selected for the averaged function, the instantaneous spectrum will also invoke overlapping; however, the minimum overlap factor will be four for these displays. If the sampling becomes discontinuous due to the specification of too high a bandwidth or overlap factor, the message 'DISCONTINUOUS SAMPLING' will be printed and the menu will appear.

3.3.4 Processed Data Display

A display of processed data is produced upon completion of the averaging process or when the STOP key is pressed. Additionally, the AVG key is used to recall a display of processed data. It may be pressed at any time, but if no valid processed data exists in memory, sampled data will be displayed. The display may be upscaled or downscaled from the fixed or auto value by hitting the ↓ or ↑ keys.

NOTE: The DISPLAY menu may be entered and parameters changed without invalidating the averaged data. The rescaled data may be viewed by pressing the DISPLAY/AVG key. However, if the FUNCTION, AVERAGE, or SENSITIVITY menus are entered the averaged data is invalidated.

3.3.5 Display Other Channels

The keys A, B, C, and D may be used after pressing any of the special function keys described above to display any input signal, instantaneous spectrum, or valid processed data available on channels A, B, C, or D. These keys will not take effect for cross correlation.

3.4 PROCESSING

Processing of the input signal is initiated by pressing the AVERAGING/START key. Averaging will proceed according to the parameters in memory. If summation averaging was specified, averaging continues to the number of averages specified by the operator. If exponential averaging is selected, averaging continues until the operator presses the AVERAGING/STOP key. After the STOP key has been pressed, averaging can be resumed at the point where it was stopped by pressing the AVERAGING/RESUME key.

While summation averaging is taking place, the number of averages which has been performed is continually updated in the annotation at the top of the display. If no instantaneous display during averaging was requested, the display which was on the screen prior to beginning remains on the screen until the averaging process is completed or stopped by the operator, at which time the results are displayed. The input attenuator, time frame size/frequency or domain cannot be changed while averaging. Hitting any key besides the STOP key will invalidate the processed data.

In exponential averaging mode, averaging to the time constant specified is continually repeated until stopped by the operator, with a new processed display produced each time the specified number of averages has been completed. The frame counter at the top of the display keeps a running total. A new display is produced when the operator presses the STOP key.

If any of the DATA REJECT options have been selected and if they apply to the current setup, each frame of data will be tested according to the options in effect. If these tests indicate "bad" data, the sample will be automatically rejected and an appropriate message will appear. This message will be erased at the next test so it may "flash" on and off the screen quickly if the data acquisition is rapid.

If the input signal exceeds the user specified full scale value during processing, an 'ADS OVERLOAD' message will appear in the upper right hand corner of the display until the condition is corrected. Such an overload can corrupt the data acquired during this time, so care should be taken to avoid this condition. If this data is averaged in the 'ADS OVERLOAD' message will appear with the processed display. If the HIGH/LOW option was selected under the DATA REJECT menu, the samples with overloads will be automatically rejected and therefore the 'ADS OVERLOAD' message will not appear with the final display. The 'ADS OVERLOAD' condition is checked only in the sample bandwidth so that if a high amplitude component is applied outside of the sampling band, the circuitry can be overloaded without a message appearing. The menu setup mode may be reentered to change various display parameters if desired. To recall the display of processed data, press the DISPLAY/AVG key. If no valid data exists in memory, sampled data is displayed. If triggering has been selected, and conditions satisfying the trigger parameters are not met, the program will hang until a valid trigger occurs. The operator can rectify this condition by pressing any key. This will cancel the operation and return the top level menu to the screen.

NOTE: The processed data in memory will be invalidated if any changes are made to the function, frequency, average, windowing or sensitivity setup menus. Entry into these menus changes the parameters identified at the top of the graticule and consequently does not indicate the condition in effect at the time of acquisition therefore the processed data is not shown.

3.5 PROCESSED DATA DISPLAY FEATURES

The processed data display offers features not available with the sampled data and input spectrum displays. These include a graphic cursor and a mechanism for expanding the x-axis (time or frequency) scale. The full scale y value for the current display may be increased or decreased by hitting the ↑ or ↓ keys. (NOTE: The RETURN key will have the same effect as the ↓ key.)

3.5.1 Graphic Cursor

The graphic cursor appears as a dotted vertical line with a cross mark at the function value whenever the averaged data display is present. The x-axis (time or frequency) and y-axis (function) values for the cursor position appear in the upper right

corner of the screen. If a Bode plot (transfer function) is displayed, the phase at the cursor frequency is also printed. Whenever the cursor is moved, or the averaged data updated, the cursor annotation is updated. The cursor position can be altered using the left arrow (←) and right arrow (→) keys. The cursor is moved to the left by tapping the left arrow key and to the right by tapping the right arrow key. The longer either key is held down or tapped consecutively, the faster the cursor will move in the chosen direction. After the cursor has been moved four lines in one direction, it begins to move more rapidly (skipping four lines at a time) until the direction is changed. The rate increases with subsequent taps (regardless of the interval between taps). When the cursor reaches the left or right margins of the display, it wraps around to the opposite margin. It should be noted that there is no valid data at the full scale x value, and therefore the cursor may not be positioned there. The cursor will remain at the same x-axis position through consecutive averaged displays, if the x-axis scaling is unchanged.

3.5.2 Display Expansion

An expanded view of the averaged data may be obtained through a special use of the cursor. This expansion operates on the averaged data in memory, and does not involve the zoom frequency translation process described earlier. The expanded display sequence is invoked by hitting the SINGLE CURSOR key (9) when in non-expanded, averaged display mode. The message:

```
EXPAND X:
SET CURSOR AT
MIN.
```

is then displayed in lower left corner of the screen. The cursor will position itself at the previous expand limit, if it exists and is valid. The operator may move the cursor position (in the usual manner) to the desired x-axis position. When the cursor is positioned to the operator's satisfaction, hit the MARK key. The x-axis value of the cursor will be saved and used as the minimum value for the next display. The message:

```
EXPAND X:
SET CURSOR AT
MAX.
```

is then displayed on the screen. The cursor will position itself at the previous maximum expand limit, and the operator may move it as desired. When the operator hits MARK, the position will be saved and a new display will be plotted using the specified limits. The point under the maximum cursor is used as a limit, but that point is not plotted. The display will remain expanded until either the SINGLE CURSOR key is hit or parameters are altered which may invalidate the limits. If the FUNCTION or FREQUENCY menus are entered, or if the display function is changed either from or to impulse response, the expanded display state will be terminated. As long as the expanded display state is in effect, new averages may be acquired, different transfer function displays (except impulse response) may be selected, and the averaged display will remain in effect. If the expanded display mode has been invoked and then terminated, with a return to non-expanded display, an expansion to the previous limits can be accomplished by going through the key sequence; SINGLE CURSOR, MARK, MARK.

A few additional points should be made: If during the expand setup sequence any key other than left arrow (←), right arrow (→), or the MARK keys are pressed, the sequence will be terminated. An expansion upon an expansion is not allowed. However, an expansion on zoomed data is permitted. If the maximum x position is set to less than the minimum and the MARK key is struck, the x-axis value printed in the upper right-hand corner of the screen will show as 0, but the actual maximum value used will be the current full scale value. This feature is quite useful, since the cursor cannot directly be set to the full scale in unexpanded displays of data. The expansion frequencies specified may also be used to set the zoom parameters, as described in paragraph 3.2.2.

APPENDIX A
ISAP DISK I/O FILE STRUCTURE

This appendix is supplied for users who wish to use ISAP-created files for subsequent post processing. It is assumed that the user is knowledgeable in FORTRAN programming and TSL data formats.

1.1 DESCRIPTION

Two types of files can be created using the DISK I/O feature of ISAP, a SET-UP file or a DATA file. A SET-UP file contains all the function and display parameters that the program needs to duplicate the current set-up. A DATA file stores all of the set-up parameters plus some additional preliminary data and the numerical data blocks. All of the set-up and preliminary data elements appear as Fortran unnormalized integers (INTEGER*2) or DEC floating point real numbers (REAL*4). Numerical data block elements are in TSL floating point real or complex format. The majority of the setup and preliminary data are ISAP dependent and are useful only as flags or display parameters to the program. A list of the independent or function-definition blocks and their location in the file follows. A brief description of each marked (*) block is also provided. The index is given in the number of Fortran INTEGER*2 words from the beginning of the file.

Beginning of File; Set-up Information.

<u>Index</u>	<u># of Elements</u>	<u>Format</u>	<u>Description</u>
0-3	4	INT	Internal
End of Record #1			
4-15	12	INT	Internal
16-66	50	INT	Menu data*
67-88	11	INT	Internal
89-90	2	REAL	Engineering Units data*
91-154	32	INT	Internal
155-157	3	REAL	ZOOM Frequency*
158-168	6	REAL	Sampling Rate
169-170	1		
End of Record #2			

NOTE

SET-UP file ends, DATA file continues

Preliminary Data Information

<u>Index</u>	<u># of Elements</u>	<u>Format</u>	<u>Description</u>
171-266	48	REAL	Internal
270	1	INTEGER	Average (Actual number of Averages)
271-276	6	INT	Internal
277-286	5		
End of Record #3			

Numerical Data Blocks*

<u>Index</u>	<u># of Elements</u>	<u>Format</u>	<u>Description</u>
287-	No of lines or resolution	TSL FP REAL	ASPEC CH A
		TSL FP CMLPX	CSPEC Ch A/Ref Chan
		TSL FP REAL	ASPEC CH B
		TSL FP COMPLX	CSPEC Ch B/Ref Chan
		TSL FP REAL	ASPEC CH C
		TSL FP COMPLX	CSPEC Ch C/Ref Chan
		TSL FP REAL	ASPEC CH D
		TSL FP COMPLX	CSPEC Ch D/Ref chan

End of File

1.2 BLOCK DESCRIPTIONS

1.2.1 Menu Data.

By analyzing the elements listed below, a complete description of the set-up and/or data can be constructed. NOTE: Elements not listed involve ISAP displays.

<u>Index</u>	<u># of Elements</u>	<u>Function</u>	<u>Value/Interp</u>
16	1	MODE	1 = SPECTRUM 2 = TRANSFER FUNCTION 3 = CROSS CORRELATION 4 = AUTO CORRELATION 5 = AMPLITUDE HISTOGRAM 6 = WAVEFORM AVERAGE
17	2	CHANNELS	1 = A 2 = B 3 = C 4 = D 5 = A, B 6 = A, B, C, D
18	3	RESPONSE CHANNEL	1 = A 2 = B 3 = C 4 = D 5 = All except ref, if 4 Ch.
19	4	REFERENCE CHANNEL	1 = A 2 = B 3 = C 4 = D

<u>Index</u>	<u># of Elements</u>	<u>Function</u>	<u>Value/Interp</u>
20	5	FREQUENCY	1 = 10 Hz 2 = 20 Hz 3 = 50 Hz 4 = 100 Hz 5 = 200 Hz 6 = 500 Hz 7 = 1 kHz 8 = 2 kHz 9 = 5 kHz 10 = 10 kHz 11 = 25 kHz 12 = USER INPUT (found by: sampling freq. / 2.56)
21	6	NO. OF LINES	1 = 100 2 = 200 3 = 400 4 = 800 5 = 1600 6 = 3200
26	11	CH A COUPLING	1 = AC 2 = DC
27	12	CH B COUPLING	1 = AC 2 = DC
28	13	CH C COUPLING	1 = AC 2 = DC
29	14	CH D COUPLING	1 = AC 2 = DC
30	15	TRIGGER MODE	1 = OFF 2 = AUTO 3 = MANUAL
31	16	TRIGGER SOURCE	1 = CH A 2 = CH B 3 = CH C 4 = EXT ANALOG 5 = EXT DIGITAL

<u>Index</u>	<u># of Elements</u>	<u>Function</u>	<u>Value/Interp</u>
32	17	TRIGGER LEVEL	1 = +FS 2 = +80% 3 = +60% 4 = +40% 5 = +20% 6 = +10% 7 = + 5% 8 = 0 9 = - 5% 10 = -10% 11 = -20% 12 = -40% 13 = -60% 14 = -80% 15 = -FS
33	18	TRIGGER SLOPE	1 = POSITIVE 2 = NEGATIVE 3 = EITHER
34	19	FRAME DELAY	given as % frame size
41	26	AVERAGING MODE	1 = SUMMATION 2 = EXPONENTIAL
42	27	NO. AVERAGES	1 = 1 2 = 2 3 = 4 4 = 8 5 = 16 6 = 32 7 = 64 8 = 128 9 = 256 10 = 512 11 = 1024
43	28	HANNING	1 = AUTO 2 = OFF 3 = ON
44	29	ENGINEERING UNITS	1 = ON 2 = OFF
50	35	OVERLAP FACTOR	1 = 2 2 = 4 3 = 8 4 = 16

<u>Index</u>	<u># of Elements</u>	<u>Function</u>	<u>Value/Interp</u>
54	39	HANNING COMP	1 = COMP (Post V 3.0)
55	40	IMPACT WINDOW	1 = OFF (Post V 4.0)
56	41	EXPONENTIAL WINDOWS APPLIED	(Post V 4.0)

1.2.2 Engineering Units Data.

This data is provided only for the user's information. The actual data in the file is not scaled or altered by the selection of Engineering Units. The necessary scaling within the ISAP program is done in this display function routine and not on the data block itself. Consequently, this block simply lists the default values (as listed below) or the Engineering Units that would be in effect if Menu (29)= 1 (on). The values are listed separately for each channel.

<u>ELEMENT</u>	<u>FUNCTION</u>	<u>DEFAULT VALUE</u>
1	Ch A - units text	'VLTS'
2	Ch A - scale factor	1.0
	units/volt	
3	Ch A - dB value at	0.0
	reference voltage	
4	Ch A - reference	1.0
	voltage	
5-8	Ch B	/'VLTS',1.,0.,1./
9-12	Ch C	/'VLTS',1.,0.,1./
13-16	Ch D	/'VLTS',1.,0.,1./

1.2.3 ZOOM Frequency.

Element 1 = center ZOOM frequency
 Element 2 = ZOOM bandwidth
 Element 3 = minimum ZOOM frequency
 Element 4 = maximum ZOOM frequency

1.2.4 Data Blocks.

ISAP searches for and writes out the valid single channel auto-spectra and two channel cross-spectra in the order listed while time domain data is written out as a single block. No file space is allocated for blocks that do not apply to the current set-up. For example, if a SPECTRUM of CH D is requested, only the ASPEC D is written to the file. If Ch A and Ch B were selected for a cross spectrum with Ch A as reference, blocks ASPEC A, ASPEC B, and CSPEC B/A(ref) would be written. CSPEC A/A does not exist so is skipped and no space is left blank. If a four channel TRANSFER FUNCTION is chosen all blocks are written out in the order listed with the exception of the CSPEC of the reference channel with itself. Time domain functions such as CROSS CORRELATION or WAVEFORM AVERAGING are written as a single block of raw time series data.

1.2.5 Comments.

- (1) The number of elements in each ASPEC or CSPEC is equal to the number of spectral lines as indicated by element (6) of Menu data. Each ASPEC element increases the index by two (REAL*4 instead of INTEGER*2) and each CSPEC element increases it by four (COMPLEX*8 instead of INTEGER*2). If time domain functions have been chosen the number of elements is equal to 2.56 times the number of spectral lines (Menu 6) times two (for REAL*4).
- (2) If ZOOM analysis is in effect, the number of spectral lines is one half the number given in Menu (6) for each spectrum. A ZOOM f(min) and f(max) (elements 3 and 4 of ZOOM FREQUENCY) correspond to the frequency at the beginning and end of the data block respectively.
- (3) All information recorded by ISAP is written out using numerous unformatted sequential write statements. The file created is contiguous without spaces or blanks. However, Fortran RT-11 inserts one, two, or three 'tag' words at the end of each physical block as block control words. These 'tag' words make normal reads difficult (at best) but are transparent to an unformatted sequential read. Therefore, to accurately read the file, several successive reads must be done in the same order and segment size as the original write. Set-up data is written in two segments or records. The first is only four words long. The second is 167 words long. In a data file, the preliminary data is recorded with 103 words followed by the numerical data blocks. Each separate ASPEC or CSPEC is written as a separate record and therefore must be read as such. The length of these records will be 2*Resolution for REAL blocks and 4*Resolution for COMPLEX blocks. Time domain data is recorded in one segment of length 2.56*Resolution*2 (for REAL). The following table summarizes the order and length of the unformatted sequential reads needed to access the files.

<u>Record</u>	<u>Integer*2 Words</u>	<u>Content</u>
1	4	Set-up
2	167	Set-up
3	103	Prelim. Data
4	(Resolution)*(Format)	DATA
5	(Resolution)*(Format)	DATA
6	as applicable	

- (4) If Fortran integer elements are read from the set-up or preliminary data portions of the file and are to be used as data in a TSL application, the TSL block exponent must be set to 15 because the Fortran integers are not normalized.
- (5) ISAP V 4.0 allows Date/Time support of data files. The ASCII code for the acquisition date and time is written as part of the preliminary data just before the numerical data blocks. The date is in the first nine (9) bytes of a three REAL*4 word variable (index 277-281) and the time in the eight (8) bytes of a two REAL*4 word variable (index 283-286). These may be accessed by reading 113 integer*2 words in the third record instead of the normal 103.

1.2.6 Examples.

- (1) The set-up and preliminary data provide the following information in the blocks as previously specified.

Transfer function, Ch A and B, Ch A ref, Ch B resp, 1kHz baseband, 200 lines resolution, AC coupling, 8/8 averages taken, no triggering, no Hanning, and no Engineering Units.

The data block would be structured as follows:

<u>Index</u>	<u># of Elements</u>	<u>Format</u>	<u>Description</u>
287-686	200	TSL FP RE	ASPEC A
687-1086	200	TLS FP RE	ASPEC B
1087-1886	200	TSL FP COMPLX	CSPEC B/A

The following unformatted sequential reads would access the file.

<u>Read</u>	<u>Index</u>	<u>Words</u>	<u>Contents</u>
1	0-3	4	Set-up
2	4-170	167	Set-up
3	171-286	106	Prelim.
4	287-686	400	ASPEC A
5	687-1086	400	ASPEC B
6	1087-1886	800	CSPEC B/A

- (2) If a time domain function is selected it might appear like this:

Waveform average, Ch C, 200 Hz baseband, 800 lines of resolution, DC coupling, auto triggering from Ch C at zero (0) level and negative slope with no delay, 20/32 averages summed with no Engineering Units.

The data block would be structured as follows:

<u>Index</u>	<u># of Elements</u>	<u>Format</u>	<u>Description</u>
548-1571	2048	TSL FP RE	TIME DATA CH C

The data could be accessed as follows:

<u>Read</u>	<u>Index</u>	<u>Words</u>	<u>Contents</u>
1	0-3	9	Set-up
2	4-170	167	Set-up
3	171-286	103	Preliminary
4	287-4382	4096	DATA

The number of elements was calculated as follows:

$$2.56 \times (\text{no. lines resolution}) = \text{No. of Elements}$$

$$2.56 \times 800 \times 2 = 4096 \text{ words for read}$$

A sample program that will read an ISAP created file and write out the important set-up parameters follows:

```

C      MAIN      DISKIO.FOR
C
C      INTEGER ISPEC(50),DEFTYP(4),MENDAT(48),WRKBUF(17000)
C      INTEGER AVGDAT,IND(10),RECS
C      DATA  DEFTYP/4*3RDAT/
C      DATA  IND/4,167,106,7*0/
C      REAL   ENGUN(16), ZMFRQ(6), SMPFRQ, DATA(8400)
C      REAL   AIB(6)
C
C      EQUIVALENCE (MENDAT,WRKBUF(16)),(ENGUN,WRKBUF(90)),
$      (ZMFRQ,WRKBUF(157)), (SMPFRQ,WRKBUF(169)),
$      (AVGDAT,WRKBUF(267)), (DATA,WRKBUF(274))
C
C      TYPE *, ' ISAP DISKIO TEST'
10     TYPE *, ' IS THE FILE: DATA=1, SETUP=2'
       READ (5,5) RECS
       IF (RECS.EQ.2) GOTO 60
       TYPE *, ' ENTER THE NUMBER OF DATA RECORDS TO BE READ'
       READ (5,5) RECS
       RECS=RECS+3
       TYPE *, 'INPUT # ELEMENTS IN EACH RECORD IN ORDER OF READ'
       READ (5,5) (IND(J), J=4,RECS)

```

```

60      WRITE (5,4)
4       FORMAT ('1FILE NAME?'/)
      IF (ICSI(ISPEC,DEFTYP,,,0).NE.0) GOTO 10
      IF (IASIGN(1,ISPEC(16),ISPEC(17)).NE.0) GOTO 980
C
C
      M=-1
      JJ=1
70      N=M+1
      M=N+IND(JJ)-1
      READ (1,END=985,ERR=990) (WRKBUF(I),I=N,M)
      JJ=JJ+1
90      IF (JJ.LE.RECS) GOTO 70
      CLOSE (UNIT=1,ERR=999)
C
C      OUTPUT DATA
C
      TYPE 100,(I,MENDAT(I),I=1,6)
      TYPE 100,(I,MENDAT(I),I=11,19)
      TYPE 100,(I,MENDAT(I),I=26,29)
      TYPE 100,32,MENDAT(32)
      TYPE 100,35,MENDAT(35)
      TYPE 100,39,MENDAT(39)
      TYPE 100,40,MENDAT(40)
      TYPE 100,41,MENDAT(41)
      TYPE 150
      TYPE 200,(I,I+3,ENGUN(I),ENGUN(I+1),ENGUN(I+2),
$ENGUN(I+3), I=1,16,4)
      TYPE 150
      TYPE 300, (I,ZMFRQ(I),I=1,4)
      TYPE 150
      TYPE 400,SMPFRQ
      NUM=2** (MENDAT(27)-1)
      TYPE 150
      TYPE 500,AVGDAT,NUM
C
C      FORMAT FOR OUTPUT
C
100     FORMAT(' MENU DATA (' ,I2,') =' ,I2
150     FORMAT(/)
200     FORMAT(' ENGINEERING UNITS (' ,I2,'-',I2,') ARE: /"',
$      A4, '" , ',F4.1,',',F4.1,',',F4.1,'/')
300     FORMAT(' ZOOM FREQUENCY DATA (' ,I1,') = ',F7.2)
400     FORMAT(' SAMPLING FREQUENCY IS: ',F7.2)
500     FORMAT(' AVERAGES TAKEN =' ,I3 ' /'. I3)
      GOTO 999
C
C      ERROR MESSAGES
C
980     TYPE *, ' CANT OPEN FILE'
      GOTO 999

```

```
C
C
985  TYPE *, ' END OF FILE ENCOUNTERED BEFORE END OF READ'
      GOTO 999
C
C
990  TYPE *, 'DISK READ ERROR'
      5  FORMAT (I4)
C
C
999  CALL EXIT
      END
```


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